SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1919.

GENERAL PHYSICS.

224. *Magnetic Escapement and Application to an Electric Clock.* **P. Sève.** (Comptes Rendus, 167. pp. 681–683, Nov. 4, 1918.)—The escapement wheel described consists essentially of a wheel round which are situated equal magnetic poles, equidistant and alternately N. and S. Various modes of arrangement are dealt with, and a description is given of the manner in which such a wheel has been used in conjunction with a pendulum, electrically maintained by Lippmann's method, to furnish a simple electric clock. A. W.

225. *New Machine for Measuring the Strength of Cast Iron by the Method of Shearing.* **C. Frémont.** (Comptes Rendus, 167. pp. 949–952, Dec. 9, 1918.)—The method of testing cast iron by means of separately cast test-pieces is not satisfactory, because, owing to differences in the conditions the results obtained give very little information as to the properties of the finished casting. The temperature of casting, rate of cooling, method of moulding, thickness and shape of the casting, etc., all influence the qualities of the finished product. It is necessary, therefore, to take the test-pieces from the actual casting, and consequently the dimensions of the samples taken must be such that the casting is not scrapped. Advantage is taken, during the machining of the casting, to drill holes with a hollow drill and the cylinder thus obtained is used as a test-piece, or a small prism may be cut out of the casting. In cast iron the shear strength is equal to the tensile strength and, accordingly, shear tests are made on the small samples thus obtained. The tests are made in a simple specially designed machine in which the load is applied to ordinary shearing blocks by means of a lever of the second class along which a spring-suspended weight can be moved. The advantage of the shear test over other tests is that it can be made on much smaller masses of metal. In the case of cast iron it possesses the advantage over the tensile test that the latter is liable to be affected by bending. F. C. A. H. L.

226. *Internal Friction of Quartz Fibres at Low Temperatures.* **C. E. Guye** and **P. Barbier.** (Archives des Sciences, 46. pp. 326–328, Dec., 1918.)—It has been found by Guye and Einhorn [Abs. 969 (1916)] that the internal

friction of quartz fibres only decreases very slowly with lowering of temperature past about — 80°. It was suggested that this departure from theory might be due to other disturbing causes, such as friction between the moving system and the residual gas. In the present work this effect has been investigated by changing the nature of the gas from air to CO_2 and then again to air, each at a pressure of about 1 cm. of Hg. The decrement was sensibly the same in all three cases, so that it may be concluded that this effect is negligible. Having regard to the known irregularities in the other characteristics of quartz at low temperatures, it is considered probable that the constancy of the internal friction at low temperatures is a real phenomenon.
J. W. T. W.

227. *Impact at Minimal Velocities.* **C. V. Raman.** (Phys. Rev. 12. pp. 442–447, Dec., 1918.)—The dissipation of energy that occurs in the impact of spheres has to be assigned principally to two causes, (*a*) the stresses occurring during impact exceeding the limits within which elastic recovery is immediate and perfect, and (*b*) the production of sound. The second may be left out of account, as it can be made as small as we please by sufficiently reducing the air pressure. According to Hertz, if two steel spheres of 2·5 cm. radius meet with a relative velocity of only 1 cm. per sec., the max. pressure developed during impact is 7300 kg. per cm.^2. Stresses of this order of magnitude would, in the case of most materials, overstep the elastic limits and result in dissipation of energy. The question naturally arises whether the coefficient of restitution can be connected in some definite manner with the magnitude of the stresses produced by impact. According to Hertz's theory, the max. pressure developed varies as the two-fifths power of the velocity before impact, and is independent of the size of the balls. Thus, by sufficiently reducing the velocity of impact, it should be possible to keep the stresses below any definite value assigned as the elastic limit, and so the coefficient of restitution for all solids should approach unity for such velocities. This was confirmed for balls of brass, aluminium, hard bronze, marble, and lead. For the latter the velocity had to be reduced below one cm./sec. [See Abs. 781 (1918.)] E. H. B.

228. *Shape of Small Drops and Bubbles.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 357–365, 1919. Suppl. No. 42c to Comm. from the Phys. Lab., Leiden.)—Mathematical discussion of the problem. E. H. B.

229. *Surface Tensions by Small Drops or Bubbles.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 366–374, 1919. Suppl. No. 42d to the Comm. from the Phys. Lab., Leiden.)—Discusses in detail a number of possible ways of measuring the surface tension of mercury, etc. E. H. B.

230. *Newton's Laws in Non-Euclidean Space.* **J. Lense.** (Akad. Wiss. Wien., Ber. 126. 2a. pp. 1037–1063, 1917.)—Mathematical discussion of the case which shows that a perturbing force occurs proportional to the reciprocal of the square of the radius of curvature of the hyperspace. E. H. B.

231. *Relation between the Experiments of Eotvös and of Foucault concerning the Rotation of the Earth.* **D. Korda.** (Archives des Sciences, 46. pp. 338–340, Dec. 1918. Paper read before the Soc. suisse de Physique, Sept., 1918.)—A general and mathematical discussion of the balance experiment of Eotvös and the pendulum experiment of Foucault without and with the gyroscope.
E. H. B.

232. *Wave Pressure on Ships.* **F. R. McMillan.** (Eng. News-Record, 81. p. 1019, Dec. 5, 1918.)—Observations taken in a special testing station, located on a pier, with instruments giving synchronous and continuous records of wave-height and water pressure, show that within the limited range of possible observation the pressure on the side of a ship is not equal to the hydrostatic head of the wave. There seems to be a dragging effect of the moving water which reduces pressure at the crest and increases it at the trough. J. W. T. W.

233. *On some Characteristics of the Equilibrium Figures of Rotating Homogeneous Fluids whose Particles Attract each other according to the Newtonian Law.* **L. Lichtenstein.** (Preuss. Akad. Wiss. Berlin, Ber. 48. pp. 1120–1135, 1918.)—In this paper the author derives some general properties of homogeneous gravitating fluids in uniform rotation. He refers in particular to the limiting hypothesis of Poincaré with respect to angular velocity. In Cartesian space x, y, z are a number of small volumes $T_j (j = 1, \ldots, q)$, whose total is denoted by T. With regard to the limit S_j of T_j, the only assumption made is that it consists of a finite number of closed double-pointless, continuous surfaces (Jordan). The volume T is occupied by a homogeneous incompressible fluid of density f whose particles attract according to the Newtonian law, and which rotates about the z axis with angular velocity w like a uniform rigid body. The Newtonian potential is denoted by $V(x, y, z)$ and the Gauss gravitation constant by K. It is first proved that the centre of gravity lies on the axis of rotation, and in section 2 that the plane $z = 0$ is always a plane of symmetry. The axis of rotation is thus a principal axis of inertia of the body. In section 3 it is established that for T to be a figure of relative equilibrium (not necessarily stable), the expression $F(x, y, z) = V(x, y, z) + \dfrac{w^2(x^2 + y^2)}{2Kf}$ must have a constant value for every component of S. Also that for the fluid to resist the tension, the resultant of the attraction and centrifugal forces must be directed within S or disappear. It is shown that the latter condition is a necessary consequence of the former. If T_0 be a separate mass of T, S_0 part of a continuous curved surface, and a any point on S, then the Green function $G_0(\bar{x}, \bar{y}, \bar{z}; x, y, z)$ regarded as a function of (x, y, z) has a continuous partial differential X of the first order with respect to S, and in particular a continuous normal differential $\partial/\partial\nu \,.\, G_0(\bar{x}, \bar{y}, \bar{z}; a)$, which for all $(\bar{x}, \bar{y}, \bar{z})$ in the interior of T_0 is $\geqq$ zero. In section 4 it is established that only the $>$ sign is permissible. It is next shown that if T consists of a finite number of fluid masses, every one of which is bounded by a continuous curved surface, then these masses are completely separated and can have no points in common. In section 5 it is proved that if T be any equilibrium figure of total volume v corresponding to the angular velocity w, then the distance R of a point from the axis of rotation depends only on v and w. It is further shown that for values of the angular velocity, $w \geqq \sqrt{(\pi \times f)}$, there cannot exist convex equilibrium figures. H. H. Ho.

234. *The Elliptic Trajectory over the Earth.* **G. Greenhill.** (Engineering, 106. pp. 393–395, Oct. 11, and pp. 424–427, Oct. 18, 1918.)—A general discussion of this question—unsuitable for treatment in a brief abstract. Various early problems are dealt with, leading up to the long-range gun. **G. B. Petter.** (*Ibid.* p. 579, Nov. 22, 1918.) L. H. W.

235. *Some Temperature Anomalies.* **H. Harries.** (Nature, 102. pp. 364–365, Jan. 9, 1919.)—Over the region of the British Isles a wind from between

W. and SW. blowing from the Atlantic is in winter naturally regarded as a warm current. The writer directs attention to certain cases when these winds are accompanied by temperatures which are not only high on the west and south-west coasts of Britain but which grow progressively higher as the country is passed over from W. to E. Thus on Feb. 23, 1918, maximum temperatures were below 50° F. along the shores of the Bristol and St. George's Channels, but reached 58° and upwards in Eastern Britain, the extreme being 61° at Halstead and Aberdeen. The day was sunny in some localities, but sunless stations in the east experienced the same remarkably high temperatures. Another notable case occurred on Feb. 10, 1899, with a maximum of 54° on the Kerry coast and continuously higher readings eastwards up to 70° at Liége. No satisfactory explanation of such a temperature distribution has been put forward. A Föhn effect has been suggested but does not seem to meet the case. In a subsequent letter (*Ibid.* pp. 384–385, Jan. 16, 1919) **W. H. Dines** suggests that these high temperatures may be due to a descending current of air. Where pressure is high the air above 2000 ft. height is warm and the temperatures noted by H. Harries may be due to a descent of this warm air to the surface. The conditions described seem generally to occur when an anticyclone lies over France or SE. England and when the higher layers of air are therefore warm. J. S. Di.

236. *Cumulus Clouds of Hawaii.* **A. M. Hamrick.** (Monthly Weather Rev. 46. pp. 415–417, Sept., 1918.)—The Koolau range of mountains in the small island of Oahu of the Hawaian group lies directly in the path of the NE. trades. Convectional cooling as the wind strikes the range and is deflected over it produces an almost permanent cloud cap and an abundant rainfall over a large part of the island. The range is 2000 to 3000 ft. high and the distribution of rainfall on the lee side is as follows: At Honolulu, 5 miles distant from the range, it amounts to 25 in. per annum, while only 2 miles from the summit it equals 100 in. The depth of the cloud from top of dome to base amounts to from 3000 to 5000 ft. J. S. Di.

237. *New Facts about the Centres of Typhoons.* **Co-Ching Chu.** (Monthly Weather Rev. 46. pp. 417-419, Sept., 1918.)—The rise of temperature which has been observed in the calm centre or "eye" of typhoons and storms of similar type has been ascribed to a descending air-current. When discussing the Manila typhoon of Oct. 18, 1882, Algué differed from this view and considered that the heating was due to solar radiation as the patch of clear sky passed overhead. The Bulletins of the Philippine Weather Bureau for the years 1904–15 disclose four cases of rise of temperature during the passage of the central calm. The most remarkable was in Formosa, Sept. 16, 1912, when the temperature rose 10° C. and continued high for a period of about two hours at the time of lowest pressure. As this occurred after sunset, Algué's theory is in this case untenable. The author is inclined to accept the suggestion of a descending current as the most probable cause. J. S. Di.

238. *Travelling Atmospheric Disturbances.* **H. Jeffreys.** (Phil. Mag. 37. pp. 1–8, Jan., 1919.)—The equations dealing with the motion of air in cyclonic depressions are considered. The following are some of the more important conclusions reached:—(1) In deducing the "geostrophic" relation between pressure gradient and wind velocity certain terms in the equations of motion are neglected, and if these terms are negligible no depression can travel. When these terms, which depend on the squares and differential coefficients of the velocities, are taken into account it is found that an asymmetrical cyclone can move, but (2) if the pressure distribution at all heights is symmetrical with respect to two perpendicular axes the depression cannot move though it may change its form subject to the condition that it must remain symmetrical with respect to these axes. (3) If a depression is formed by the simple superposition of a pressure field of straight parallel isobars upon a circular cyclonic system, the velocity of translation of the system will be much greater than the general velocity of the winds around the cyclone. Since this is not so in actual cyclones, it seems that the effect of superposing a general pressure gradient on a mass of rotating air is to cause a considerably smaller change in its symmetry than would be expected. Some internal compensation reduces the asymmetry. J. S. Di.

239. *Note on Tsunamis.* **S. Nakamura.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 548–555, Dec., 1918.)—A "tsunami" denotes an unusually high rise of the sea, or tidal bore, which is sufficiently accentuated to do some damage. These disturbances are not infrequently observed on the coast of Japan, and are due either to seismic or meteorological causes. In those caused by a submarine earthquake the train of waves may continue for a time varying from a few hours up to a few days. The period of the waves is a few tenths of an hour. Examples of this type are quoted, and it is shown that the wave sent out is not symmetrical in all directions. The amplitude varies greatly in different directions and the phase is also different, the same tsunami being first felt at some stations as an upward motion of the water and at others as a downward motion. Diagrams showing the phenomena at different stations are reproduced. The tsunamis due to strong typhoon winds are felt in the Bay of Tōkyō on an average once in 12 years, though the distribution is not uniform and they tend to group themselves two or three together with a period of about 30 years. A SSE. wind is the most favourable for their development, and there is a close relationship between the height of the wave and the extreme wind measured at Tōkyō. In addition to the raising of the water-level by the wind secondary undulations are also set up in the bay. J. S. Di.

240. *Penetration of Periodic Temperature Waves into the Soil.* **K. Aichi.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 527–541, Dec., 1918.)—The paper deals in a theoretical manner with the conduction of heat through a substance such as the soil. In working out the annual temperature wave at depths of 1 m., 2 m., and so on from that at the surface it is customary to assume the conductivity and specific heat constant throughout each layer. This is far from being the case, and it is shown that the assumption invalidates the results of such calculations. The ratio of the conductivity to the specific heat can be obtained (1) from the change of amplitude of the temperature wave with depth, and (2) from the retardation of phase, and in certain practical examples to which the formulæ are applied in the customary manner it is found that the results from (1) and (2) are in very poor agreement. In the paper certain cases where the conductivity varies with depth in a specified manner are treated mathematically. J. S. Di.

241. *Notes on Kite Flying.* **V. E. Jakl.** (Monthly Weather Rev. Suppt. No. 13. pp. 7–12, 1918.)—The paper contains hints on kite flying and describes the different types of weather conditions which are likely to lead to breakage of the wire or other damage if care is not used. No useful summary can be given. J. S. Di.

242. *Early History of the Solar System.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 78. pp. 424–442, April, 1918.)—It is first shown that the existing planets cannot have been formed by the slow condensation of a gaseous mass moving in any plausible way, however its density was distributed. For this and other reasons the tidal theory of the origin of the solar system is adopted. In the second section the effect of the gaseous matter set free in the initial disruption and not collected into the nuclei is considered. On the supposition that it was of such density that, before its own viscosity caused it to dissipate, its resistance had reduced the eccentricities of planetary orbits to the extent required by the theory and by their present state, estimates of its density and of the age of the system are obtained. The latter agrees surprisingly well with the age of the earth determined by its radio-active constituents, though it rests on uncertain data and will need subsequent revision. After a short time the medium would be forced by the reaction of the great planets upon it to revolve around the sun so that the planets had little motion in longitude relative to it. It is further shown that the angular velocity at any point of the medium multiplied by the fourth root of the distance from the centre is a function of the distance from the polar axis only. The great planets would be surrounded by distended masses of denser matter moving with them, and it is to the resistance of the medium to the large surfaces exposed by these that the comparatively small eccentricities of the great planets are to be attributed. The moon is the only satellite likely to have been less affected by the resisting medium than by tidal friction.

It is next shown that any planet or satellite whose present diam. is less than 1000 km. could never have been gaseous, as its gravitative power would have been unable to hold it together. The smaller members of the system must therefore have been liquid when first formed. The asteroids were probably formed from a primitive planet which approached Jupiter so closely as to be broken up by tidal action, and their present motions appear to agree fairly well with this theory.

The moon is the only satellite that can have been formed by resonance; but if Saturn was no more strongly condensed towards the centre than the earth is, it would have been likely to produce one in this way. The absence of such a satellite confirms the result indicated by the ellipticity that Saturn is on the whole relatively more dense in the centre than the earth. Adopting, on the other hand, the hypothesis that Mercury rotates in about 24 hours, it is shown that it must have once had a greater angular velocity than that needed for resonance. It is suggested that the absence of a satellite from Mercury might be accounted for if Mercury was itself once a satellite of Venus; but on examining this hypothesis quantitatively it is found that the eccentricity of the orbit could never have been so great as it actually is. Hence Mercury can never have rotated with the speed needed for resonance, and the action of solar tidal friction has been enough to make it always keep the same face towards the sun. The rotation of Venus is quite uncertain; and none of the superior planets except perhaps Mars can have been much affected by solar tidal friction. The only planets dominated by tidal friction are therefore Mercury and the earth. AUTHOR.

243. *Law of Internal Density in Solar Theory.* **E. Bélot.** (Comptes Rendus, 167. pp. 753–756, Nov. 18, 1918.)—The values of the sun's internal density according to Lane, Thomson, and Véronnet are respectively 8·4, 81·5, and 1·41. The present author discusses the discrepancy, pointing out the radiation-pressure mentioned by Eddington and also the nullifying effect of enormous pressures on the dissociation expected with high temperature. He notes also that the expression ordinarily used for the density (*e.g.* by Poincaré) becomes infinite at the centre. He therefore suggests a homogeneous central core and works out the effect of choosing various radii for this core within which the variation of density with depth ceases, and finds a probable law intermediate between the inverse cube and inverse square. If his central core is nearly as large as the whole body, Véronnet's value holds, the other two belonging to values of the radius of the core of $\frac{1}{3}$ and $\frac{1}{6}$ respectively of the sun's radius. W. W. B.

244. *Satellite Matter on Surface of Sun, Earth, and Planets.* **E. Bélot.** (Comptes Rendus, 167. pp. 1030–1033, Dec. 23, 1918.)—Starting from his previous hypothesis [Abs. 370 (1918)], which includes equatorial protuberances with satellites, the author obtains possible values for distances of condensing matter from the surfaces of planets. The amount of this matter which he finds, varies from about 1 % in the case of the earth and rather less for Venus and Mars to 9 % for the sun and 60 % for Jupiter. He endeavours to account for the bands of Jupiter and similar appearances on the same hypothesis of deposited satellite matter, finding a limit of 57° for the latitude of disturbances on Jupiter and about 27° for the sun. Similarly he explains the more rapid rotation at the equator of the sun and the anomalies of rotation of Jupiter. W. W. B.

245. *Relation between Elements of Planets and Satellites.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 79. pp. 106–108, Dec., 1918.)—The author discusses a formula given some years ago by M. F. Ollive, namely: $r^3 = KRR^1V^2$, where r is radius of planet, R its distance from the sun, R^1 the distance of a satellite from the planet, and V its orbital velocity, K being a constant [Abs. 621 (1914)]. He shows that this reduces easily, neglecting very small terms, to a form in which the elements of the satellites do not appear, and ultimately to the simple relation: Density of planet varies inversely as distance from sun. Tabulating this, he shows that it is only approximately true for the middle planets from Venus to Saturn, but quite inapplicable to Mercury, Uranus, and Neptune. W. W. B.

246. *Total Solar Eclipse, June 8, 1918.* **W. W. Campbell.** (Lick Observat., Bull. 10. pp. 1–3, 1918.)—This note deals only with the position of the station at Goldendale, Washington, of the Lick Observatory–Crocker eclipse expedition, and the times of contact observations, which proved the eclipse to take place nearly 17 seconds earlier than the time given by the Nautical Almanac, which, however, had been corrected in accordance with R. H. Tucker's observations of the moon, so that the tabular time had been advanced 20 seconds. The good fortune which provided a break of four minutes' duration in a cloudy sky just allowed the whole of the eclipse to be observed, but the author emphasises the importance of afternoon meteorological observations in addition to the regular morning and evening observations which neither here nor in the Crimea (for the August 1914 eclipse) gave any hint of cloudy and dusty conditions which were found to be prevalent at the time of the eclipse. This should be borne in mind when obtaining meteorological data for the choice of eclipse stations. W. W. B.

247. *Nature of Sun-spots.* **G. E. Hale.** (Roy. Soc., Proc. 95. pp. 234–236, Jan. 1, 1919.)—Traces the author's investigations in three directions:

(1) Widened lines in sun-spot spectra. (2) Spectroheliograph applied to whole surface. (3) Laboratory experiments to provide interpretation. Commencing in 1891 at Kenwood Observatory, the equipment was insufficient to show any currents in bright Ca flocculi. But at Yerkes Observatory in 1903, with greater power, indications of fields of force centring in sun-spots were found, and later in 1908 at Mt. Wilson, with further increase of power, sharply defined vortices were photographed. With the 60-ft. tower telescope strong evidence was found that sun-spots are electric vortices. And now with the new 150-foot tower telescope a daily record is maintained of the field-strength and magnetic polarity of all sun-spots. Many of them occur in pairs of opposite polarities, and the sign of the polarity of the leader is different in opposite hemispheres, just as in cyclones on the earth. Moreover, the sign of the polarity of the leading spots is found to differ at different phases of the sun-spot cycle. Experiments are suggested to explain the formation of a semi-circular vortex ring resembling the appearance of a pair of spots of opposite polarity and also to reproduce the inward, downward and outward circulation indicated in the solar hydrogen vortices.

An electromagnetic hypothesis is also indicated, but though the investigation throws more and more light on the nature of sun-spots, no evidence has yet been found of the existence of electric fields in the sun. W. W. B.

248. *Solar Eclipse May 29.* **A. C. D. Crommelin.** (Nature, 102. pp. 444–446, Feb. 6, 1919.)—This gives an account of the programme for the forthcoming eclipse of May 29, two parties being sent by the Joint Permanent Eclipse Committee of the Royal Society and the Royal Astronomical Society. Totality will be unusually long, 6 min. 50 secs. in mid Atlantic. This particular series of eclipses is gradually increasing its duration and will reach a maximum of 7 min. 8 secs. in June, 1955, the longest for 1000 years. The totality track crosses the whole width of S. America and Africa, so the longer totalities will be on the east of the former and west of the latter. Crommelin and also Davidson from Greenwich are going to Sobral in Brazil, Eddington and Cottingham to the island of Principe off the W. Coast of Africa. The sun being in the Hyades at the time, several comparatively bright stars should be visible near the limb during totality, and the main object of the expeditions is to photograph these in order to compare the result with photographs of the same region in the absence of the sun, as a direct test of the validity of Einstein's theory, which computes a displacement of rays passing near the sun. In the interval between the time of eclipse at the two stations (2 min. 19 secs.) the sun will travel 6·80′, strengthening the test by allowing a comparison of the relative shifts, if any. Eddington has suggested a shift due to gravitational effect on the energy of waves passing near the sun, amounting theoretically to half the quantity required by Einstein's theory of relativity, so the author points out that there are three cases: whole shift, half shift, and no shift. W. W. B.

249. *Relative Numbers and Areas of Sun-spots E. and W. of Central Meridian,* 1902–1917. **R. J. Pocock.** (Roy. Astron. Soc., M.N. 79. pp. 54–58, Nov., 1918.)—Mrs. Maunder found a distinct excess on the E. side for the period 1889–1901. The present paper extends the investigation for a further period, with certain modifications in the method adopted, so that the figures are not strictly comparable for the two periods. The author finds a much smaller E. excess, but thinks it too definite to be fortuitous. It is more marked when the number of spots is rapidly changing either way, disappear-

ing at maximum or minimum. The year 1908 is abnormal, but an explanation is suggested. There is a difference between N. and S. hemispheres. Taking areas instead of numbers, the E. excess is much less and is not so systematic year by year, some giving a W. excess. This is especially the case in years of maximum and minimum. After 1910 the prominences also show an E. excess, still less marked; but before that date the observations were mainly visual and appear to be biased. W. W. B.

250. *Displacement of Solar Lines reflected by Venus.* **J. Evershed.** (Observatory, 42. No. 535. pp. 51–52, Jan., 1919.)—The author has been testing the light from the "back" of the sun, reflected from Venus, in comparison with that from the side facing the earth, and finds a difference which he can only ascribe to an effect of the earth on the sun, already suggested in the case of sun-spots. A blank test consisting of comparison of spectra through a solar rotation shows that the sun itself is not the cause of the difference, since the iron-arc displacements are practically constant whatever face the sun turns to the earth. All the Venus plates show a shift in the opposite direction, indicating that the shift is not gravitational. W. W. B.

251. *Curious Feature on Jupiter.* **F. Sargent.** (Nature, 102. p. 432, Jan. 30, 1919.)—A luminous protuberance was observed at Bristol on Jupiter's E. limb on Jan. 16, and on the W. limb on Jan. 17 it was faint when in the centre of the planet. Not being an effect of irradiation, as bright spots on Mars generally prove, it is likely that these observations are of a real prominence. W. W. B.

252. *Distances of Six Planetary Nebulæ.* **A. van Maanen.** (Nat. Acad. Sci., Proc. 4. pp. 394–396, Dec., 1918.)—Six planetary nebulæ have been photographed specially with the 60-in. reflector at Mt. Wilson for parallax determination. One of them, N.G.C. 7662, was the subject of a previous paper [see Abs. 477 (1917)]. From the three tables given in the paper the following results appear :—

N.G.C.	Parallax.	Abs. Mag.	Diameter in Astr. Units.
2392	0·022″	6·7	2100
6720	0·008	9·2	10,000
6804	0·022	10·1	1450
6905	0·015	10·4	3100
7008	0·016	8·8	5900
7662	0·023	9·7	1350

The solar system as far as Neptune has a diam. of 60 Astr. units, so the nebulæ are of enormous size.

A relation between novæ and planetary nebulæ is suggested by the nebulosity photographed round Nova Persei, and other conclusions are drawn as to the possible cause of the low absolute brightness of the nebulæ. W. W. B.

253. *Cause of Distance-Velocity Equation in Stellar Motions.* II. **C. D. Perrine.** (Astrophys. J. 48. pp. 295–302, Dec., 1918.)—A further contribution to the discussion [see Abs. 1075 and 1076 (1918)] between the author and Adams and Strömberg. To their objection that his view of the case attaches too much importance to the position of the sun he replies by several suggestions, raising the general question of the validity of parallax determinations, on which observations by Zimmer are throwing considerable doubt, and pointing out that large proper motion is not necessarily associated with large parallax; though faint stars with large proper motion are, he thinks, unfairly included in the parallax determinations, inasmuch as they are not typical of all stars of the same apparent faintness. He also returns to his hypothesis of regions of cosmical matter, and suggests that stream motion would give an even closer relation to distance, showing how the position of an observer would affect systematically his determinations of radial velocity. For really definite conclusions he awaits more voluminous data and more certain parallax determinations. W. W. B.

254. *Pulsations of a Gaseous Star, and the Cepheid Problem.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 79. pp. 2-22, Nov., 1918.)—Convinced that Cepheid variables are not binary stars, the author examines the hypothesis of pulsation, attempting to solve, with some restrictions, the general problem of conditions resulting from the hypothesis. For simplicity spherical pulsations are assumed, and a regular variation of average temperature with type is adopted resulting in values for classes A_0, F_0, G_{b0}, and K_0 of 11,200°, 8200°, 6000°, and 4400° respectively. On this assumption the radiation for unit area is deduced, and this, in conjunction with the total radiation given by the bolometric magnitude, gives the surface area and hence the radius. The mass being a function of the absolute magnitude is next deduced, giving the mean density. The elements of a supposed binary reproducing the phases of velocity indicated, provide a secondary within the primary, hence confirming the rejection of the binary hypothesis. There is an uncertainty in the spectral type of the 14 stars used as sufficiently well determined, since they are based on measurements of the H lines only and not on the general spectrum. On the pulsation theory the changes of volume will involve changes of temperature of very large range in the interior, so the possibility of rapid dissipation of the energy is considered, as this would speedily put a stop to the pulsations. It appears, however, that owing to the high interior opacity the vibrations near the centre are nearly adiabatic, and under these conditions a trial solution is found without much possibility of considerable error, since near the boundary where the adiabatic conditions cease to hold good a very small change one way or the other has an obvious effect, and the trial solution must be very near the truth. The resulting values are applied to δ Cephei as a typical case. Owing to the uncertainty of the type determination there are two ranges to be considered, according to whether the general spectrum has been used or only the H lines. The range in the one case is from 7·22 to 2·88 days and in the other from 10·01 to 4·01 days, so that in either case the actual value of 5·37 days contradicts nothing. The period varies inversely as the square root of the density to a close approximation. But the author considers that since the periods of Cepheids can be determined with such extreme accuracy (seven significant figures are often given in ephemerides) a change of period might very likely be measurable. Again taking δ Cephei as typical, he finds values for the exhaustion of potential energy and for the annual radiation. He concludes that the period should decrease by 40 seconds annually, on the hypothesis that the energy of contraction provides all the heat necessary. No such diminution has been observed, and Chandler's estimate of the decrease of period is only $\frac{1}{20}$ sec. annually. It seems, therefore, that the energy of contraction does not provide sufficient heat for the radiation. Taking Chandler's value for the annual change, the author computes that δ Cephei would take ten million years to pass from Type G to F.

Sufficient theoretical relations are now available to determine the other elements of condition of a Cepheid when one is given, and the author works out numerical details for the case in which the given element is the absolute magnitude, and shows a qualitative agreement with the statement of Shapley that the longer the period the later (redder) the type, but quantitatively the agreement is not so close, though it agrees better with Shapley's more recent figures. It appears that any modification of the figures from the other side will induce a still closer agreement, as the theory will advance to meet any concession.

This paper being mainly confined to theoretical determination of period, another is promised dealing with rate of decay of pulsation and its limiting amplitude and a few other points connected with the unsymmetrical shape of the velocity curve, etc. W. W. B.

255. *Constant and Probable Errors of Greenwich Astrographic Catalogue.* **J. G. Porter.** (Astron. J. 31. p. 200, Dec. 19, 1918.)—By comparison both with the Cincinnati Proper Motion Catalogue and also with Boss's Preliminary General Catalogue, the author finds the probable error of the Greenwich catalogue to be 0·24″ in both elements. He considers, therefore, that the accuracy of the photographic catalogue is not greater than that of visual catalogues, and that the best meridian instruments, if located where definition is uniformly good, should give results of an accuracy superior to that of the photographic method. W. W. B.

256. *Stars with Large Proper Motion in Hyderabad Zones.* I. **R. J. Pocock.** (Roy. Astron. Soc., M.N. 79. pp. 49–53, Nov., 1918.)—After precautions to guard against the inclusion of stars whose apparent motion is due to errors of observation or catalogue, and after omitting stars from the lists of Boss, Porter, and van Maanen [see Abs. 1004 (1915)], the author gives a preliminary list of 85 stars with centennial P.M. ranging from 14″ to 114″ ; the larger ones being confirmed elsewhere as indicated in the notes. W. W. B.

257. *Relation between Mean Parallax and Magnitude.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 79. pp. 45–49, Nov., 1918.)—Taking the published list of 500 stars with luminosities and parallaxes by the new spectroscopic method, the author tests the validity of the simple formula $m\omega = c^3$, and finds that it will not do. He then tries a formula of Kapteyn's form, namely, $\log \omega = a + bm$, tentatively using $\log m$ instead of m, the agreement in this case being much better, though the mean parallax of the brighter stars given by the formula is too small.

For the dwarf stars and the fainter giants, *i.e.* all stars fainter than 5th magnitude, he finds Kapteyn's formula in very good agreement, and confirms Kapteyn's value of the rate of increase of distance with decreasing apparent brightness. W. W. B.

258. *Evolution of Binary Systems.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 79. pp. 100–106, Dec., 1918.)—The effect of one star on another being quite infinitesimal, as also that of the universe on the angular momentum of a star, this latter element can be taken as a constant. In the case of the solar system this angular momentum is too small for the system to have broken up by rotation. The present paper considers the case of binary stars, most of which have angular momentum too great for them to have broken up by rotation. The author finds the latus rectum to be practically constant so long as the orbit (of a binary) is unaffected by forces from without. Now the periods of these stars range from a few hours up to centuries, and Campbell has found that longer periods and higher eccentricities belong to advanced spectral types, and has suggested continuous lengthening of the period by tidal friction. The present paper shows this to be untenable, and leaves two possible alternatives: (1) No variation at all; (2) no variation now, but evolution in some distant period in the past, when interaction was more powerful between stars. This latter hypothesis is adopted as the only possible one consistent with dynamical theory.

The author concludes that the long-period binaries are of old-established stability, but that the B-type stars and the short-period binaries are of comparatively recent origin, and that the process of expansion is still taking place, as indicated by the observed positive excess of radial velocities of stars of all types. W. W. B.

259. *Meteor Shower from Pleiades.* **A. King.** (Roy. Astron. Soc. M.N. 79. pp. 158–160, Dec., 1918.)—From his own and Cranidge's observations at Ashby, North Lincolnshire, the author deduces a radiant at 55° + 25° approximately with a max. frequency on Nov. 12 at 10.40 p.m., which he considers quite independent of the neighbouring known radiants associated with ε Tauri, ζ Persei, and ζ Arietis. W. W. B.

260. *Relations between Rectilinear Coordinates of a Star shown on Two Overlapping Plates.* **B. Baillaud.** (Roy. Astron. Soc., M.N. 79. pp. 151–157, Dec., 1918.)—Geometrical problems showing how to connect measures on overlapping plates in different aspects of the question, according to the data supposed given, whether in actual coordinates measured on the plates or by the direction and length of arc joining the plate centres, or by declinations and difference of R.A. of plate-centres. W. W. B.

261. *Simultaneous Photography of Stars in Two Different Parts of the Spectrum.* **M. Maggini.** (Comptes Rendus, 167. pp. 719–722, Nov. 11, 1918.)—Nordmann and Tikhoff having independently determined, the former by his heterochrome photometer and the latter by photography, that four rapid variables, namely β Persei, λ Tauri, RT Persei, and W Ursæ Majoris, have minima not simultaneous in all parts of their spectra, the author has applied monochromatic photography for the same purpose. By means of a coloured liquid between parallel glass plates, the front one thick enough to discriminate between deflections from its two surfaces and the one behind the liquid silvered on its front face to counteract the dimness produced by absorption, he obtains a series of monochromatic images in a straight line, according to the number of internal reflections. He uses four different filters corresponding to λ = 645, 558, 412, and 335 μμ respectively, and has so far employed his method on twenty variables, mostly of Algol type from Parkhurst's Yerkes list, and has obtained exact data in regard to the Nordmann-Tikhoff phenomenon. W. W. B.

262. *Preliminary Orbit of the Spectroscopic Binary δ Columbæ.* **R. E. Wilson and C. M. Huffer.** (Lick. Observat. Bull. 10. [Circ. No. 318] pp. 15–16, 1918.)—The binary character of this star (R.A. 6 h. 18·4 m.; decl. − 33° 28′; magn. 4; class G5) was announced by Palmer in 1905. Its orbit has been computed from 25 spectrograms with the 3- and 2-prism spec-

trographs of the Mills expedition. The results and corrections are tabulated and the preliminary elements given ($P = 870$ days ; $e = 0{\cdot}67$; $V_0 = -5{\cdot}9$; etc.). H. F. H.

263. *Bordeaux Magnitudes.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 79. pp. 136–148, Dec., 1918.)—This is the 13th note on stellar magnitude scales of the Astrographic Catalogue. Bordeaux zone + 17° has been considered in an earlier paper [see Abs. 1511 (1912)], so this extends the investigation to zones + 16°, + 15°, and + 14°. Large differences are shown, which apparently cannot be explained by any published instrumental change, the absence of which is expressly stated in the Bordeaux volume dealing with zone + 16°, and inferred by omission in the other two. As in previous papers, the data are re-tabulated after correction for galactic condensation and analysed harmonically in different zones and magnitude groups as well as *en masse.* The author considers that in view of the great discordances found, the original work must be re-examined before any further scale comparison can be worth while. W. W. B.

264. *Dark-line Spectrum of Nova Geminorum No. 2.* **J. Lunt.** (Roy. Astron. Soc., M.N. 79. pp. 130–136, Dec., 1918.)—After preliminary measurement of spectra of Nova Aquilæ [see Abs. 36 (1919)], three of the enhanced Ti lines appeared on comparison to be found also in spectrum of Nova Geminorum 1912, and careful examination reveals the fact that on displacing one set by an amount corresponding to a radial velocity of 777 km. per sec., more than 20 other lines are common to the two spectra, most of which are enhanced Ti lines, a few being enhanced Fe or Cr, and others He or Se.

In the light of this confirmatory evidence, the author traverses some of the conclusions of Lockyer and Baxandall in 1914 when they cast doubts on the reality of dark absorption lines.

The H lines indicate a higher velocity than the metallic lines—a result said to be consistent with the idea of violent eruptive activity.

Several other identifications of less definiteness can be found on the same assumption of a large displacement, but there is considerable uncertainty in the measures. The author's opinion is that the high velocities indicated by the enhanced metallic lines are real, and that the small velocities attributed to novæ in general belong not to the star, but to gaseous material left behind in the passage of the star through a nebula. W. W. B.

265. *Nebulosity round Nova Persei.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 79. pp. 28–31, Nov., 1918.)—Since the enormously increased power of instruments now available makes more likely a real determination of the question of polarisation of the light of the nebula surrounding Nova Aquilæ, a question left undecided in the case of Nova Persei, the author returns to the consideration of the latter, on the assumption that the light observed was reflected from a nebula and with the idea that a nova may be the result of the collapse upon its centre of a diffused non-rotating nebula. Varying the details of his hypothesis to meet certain difficulties, he arrives at a probable value for the dimensions in the case, and among them a distance of 350 light-years, so that the outburst of Nova Persei would be dated 1551. Another difficulty is that the nebulosity was not centred accurately round the nucleus as required by the hypothesis, and it is suggested that tidal action will be sufficient to account for the varying amount of this eccentricity.

W. W. B.

266. *Period of V Tucanæ.* **B. H. Dawson.** (Astrophys. J. 48. pp. 310–318, Dec., 1918.)—From 148 visual observations this proves to be an eclipsing variable, with period about 21 hours. The author has compared also the original Arequipa plates from which Miss Cannon discovered the variability, and obtained a formula giving the minima for several years to come with an error which cannot reach 4 minutes until after ten years. The period is sensibly constant. The loss of light during eclipse is 1·8 magnitude, most of which takes place within 2 hours, half a magnitude being lost in 12 minutes close to the minimum phase. The absence of sufficient well-determined faint comparison stars postpones the accurate determination of the elements. W. W. B.

267. *Radial Velocities of* 119 *Stars observed at the Cape.* **J. Lunt.** (Astrophys. J. 48. pp. 261–278, Dec., 1918.)—Of a list of 365 stars down to 4½ magnitude, this paper, on account of war conditions deals only with 119 of the brighter stars, of which 43 appear to indicate variable velocity. A Hartmann spectro-comparator was used with an iron comparison spectrum. Probable errors are computed for the determinations, the general accuracy being tested by a large number of spectrograms of 18 of the brighter stars. Comparison is made with results from other observatories for such stars as have been observed elsewhere, including Lick, Chile, and Bonn, and the Emerson McMillin Observatory at Columbus, systematic corrections being applied where found, reducing the average discordances to a fraction of a km. per sec. The instrument used is the 4-prism spectrograph of the 24-in. Victoria telescope, a narrower slit being employed for the brighter stars. W. W. B.

268. *Absorption Spectrum of Novæ.* **W. S. Adams.** (Nat. Acad. Sci., Proc. 4. pp. 355–360, Dec., 1918.)—Absorption lines greatly displaced towards the violet are a marked feature of bright novæ at a certain stage of their development. Many of the lines are enhanced lines of Fe, Ti, and Cr, a few being arc lines. Careful comparison shows the displacement to be proportional to the wave-length, and to be twice as great for the two brightest, Nova Persei and Nova Aquilæ, as for Nova Aurigæ and Nova Geminorum. In the case of Nova Aquilæ, the apparent displacement at λ4500 increased about ½ Å. per day for one period in June. In the cases of Nova Geminorum and Nova Aquilæ a second series of lines showed a still greater displacement, so that the three values of approximately 11, 22, and 33 Å. represent nearly all the displacements measured in all four of the stars, leaving four narrow Ca and Na lines almost undisplaced, to determine the radial velocity of the stars themselves, on the plausible assumption that the large displacements are those of an outer envelope. But definite interpretation of the phenomena is difficult. Neither the Zeeman-effect nor pressure could be reconciled with the narrowness of the lines. The very high indicated velocities, exceeding 2000 km. per sec., make it difficult to accept a simple Doppler-effect which otherwise fits the conditions. Rapid changes in the thickness of a stratum of absorbing gas have been suggested or in its refractive index. On the whole the author is inclined to the view that a shell of gas is rapidly driven outwards from the star's surface, the small section of which in direct line with the star gives absorption lines, while the remainder gives an emission spectrum. Even in this there are admitted difficulties, and dissociation may have to be invoked, especially in regard to the harmonic values of the observed displacements, to which attention has been drawn. [See Abs. 1231 (1918).] W. W. B.

269. *Stellar Clusters.* VIII. 189 *Cepheid Variables.* **H. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 153. Astrophys. J. 48. pp. 279–294, Dec., 1918.)—In continuation of previous work [Abs. 84 (1919)] the author applies his luminosity-period curve to determine absolute magnitudes and parallaxes of Cepheid variables. 174 are passed in review, of which 139 are tabulated as true Cepheid variables, with periods ranging from about 3 hours to 40 days; the remaining 35 form a separate table, including those with periods greater than 40 days, and others with various irregularities which in the author's opinion are not proved to be typical Cepheids, so that the method is inapplicable to them. Of the 139 stars the average probable error of the parallax determinations is given as 20 %. As more of them are in south galactic latitude, it is inferred that the solar system lies rather to the north side of the plane of galactic concentration. 45 out of the 139 are of the cluster type with luminosity rather more than 100 times that of the sun. The remaining 94 are ordinary Cepheids with periods longer than a day and brightness ranging from 200 to 10,000 times that of the sun. Less than one in three has a parallax greater than a thousandth of a second of arc. The most distant Cepheids are nearly 20,000 light-years distant from the sun. The nearest globular cluster is at a distance of about 21,000 light-years. The distribution in space of these stars shows the concentration of the Cepheids with periods greater than a day towards the galactic plane, but the 45 cluster-type variables with shorter periods, mostly about half a day, are more scattered—possibly, according to the author, on account of their very high velocities in space. W. W. B.

270. *Distribution of the Stars in Space.* **G. Deutschland.** (Phys. Zeits. 19. pp. 286–295, July 1, 1918.)—Deals with the methods and assumptions employed by the various investigators, beginning with W. Herschel and concluding with H. v. Seeliger, in their attempts to arrive at a correct idea of the distribution of the stars in space. Seeliger's hypothesis is then considered at greater length under the following headings: Star numbers and parallaxes; Apparent and spacial distribution of the stars; Star distribution and the Milky Way; The distribution functions. L. H. W.

271. *Parallax of Barnard's Proper-motion Star.* **S. Kostinsky.** (Astron. Nachr. No. 4971. Nature, 102. p. 413, Jan. 23, 1919. Abstract.)—The author has determined the parallax of this star by photography at Pulkova, obtaining 0·622″ ± 0·022″, the American values being about 0·53″. He gives P.M. in R.A. −0·0438 s., in decl. + 10·249″. W. W. B.

272. *Distribution of O-type Stars in Space.* **W. Gyllenberg.** (Ark. för Mat., Astron. och Fysik, Stockholm, 11. No. 28. pp. 1–19, 1916–1917.)—The author follows Charlier's method and adopts his assumed relation between spectra and absolute magnitudes. There are in the Harvard list 107 O-stars of which 6 are omitted for want of definiteness in type or because magnitude is not known. Of the 101 remaining stars 23 only have well-determined proper motion and of these 23, 17 belong to the type Oe 5. Hence special investigation is made of these, and they agree closely with helium stars in the resulting distance of a zero-magnitude star and in velocity distribution and extension in space. The O-stars as a whole are fairly accordant also with the helium stars, but show greater extension in the galactic plane. To reconcile them closely requires an improbable assumption that they are of a low luminosity and have galactic condensation four times as great as the helium stars.

The max. density of the O-stars at the centre of gravity of the galactic system is evaluated at 0·0000190 stars per cubic siriometre, that in the neighbourhood of the sun having a smaller value, the significant figures being 178 instead of 190. A comparison is given with Hertzsprung's similar investigation using different units. W. W. B.

273. *Distance and Velocity-distribution of A-type Stars.* **K. G. Malmquist.** (Ark. för Mat., Astron. och Fysik, Stockholm, 11. No. 29. pp. 1–20, 1916–1917.)—Applying the method adopted by Charlier for the B-stars, the author deals with 1459 stars of sub-classes B8 to A5; the bulk of them being A0 separately for stars brighter than 5th magnitude, for those between 5th and 6th magnitude and then for all down to 6th magnitude. He finds the density within 20 siriometres of the sun to be 0·0218 stars per cubic siriometre (1 siriometre = 15·79 light-years). Further accuracy is hoped when the promised Harvard list of 220,000 classified spectra is available. Some of the deduced parallax values are compared with determinations by Kapteyn and Weersma. The velocities are expressed in siriometres per stellar year (4·7375 km. per sec.) and the velocity ellipsoid is determined both for the whole set of stars used and also excluding the B8 and B9 sub-classes. W. W. B.

274. *Dynamical Problems of the Stellar System.* **A. S. Eddington.** (Observatory, No. 524, pp. 132–137, March, 1918.)

275. *Spectrum of Nova Aquilæ*, 1918. **A. L. Cortie.** (Roy. Astron. Soc., M.N. 79. pp. 121–130, Dec., 1918.)—The Stonyhurst photographs were taken with 3-in. achromatic with objective prism as used for Nova Persei but with rather greater dispersion, the region photographed extending from λ5180 to λ3670 (H_λ). The four bright bands adjoining H_β, H_γ, H_δ, and H_ϵ had a mean width of 55 Å.U. which remained apparently unaltered for two months at least. The author considers that this fact points to pressure rather than motion. Reproductions are given for June 10, 11, 15, 24, 30 and July 29, with a comparison spectrum of α Cygni, to which that of the nova shows marked resemblance. Wave-lengths are given for more than 130 lines and nearly fifty bands, many of them composite. Most of the identifications are H, Fe, Ti, and Cr, but He, Ba, Mg, Zr, C, and Si also appear in the list. **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 12. pp. 494–510, Dec., 1918.)—In continuation of a previous paper [Abs. 1066 (1918)]. This gives data from observations with the single-prism spectrograph of the Dominion Observatory at Ottawa. The author claims for the star on June 9 a magnitude of − 1·5 (slightly brighter than Sirius) indicating about 100,000-fold increase in brightness in not more than four (possibly three) days. By June 29 the magnitude decreased to 3·8 and then for some time, while still fading on the whole, oscillated in periods of about 11 days through rather more than half a magnitude. By the end of Aug. the fluctuations became much less. Corresponding oscillations observed in Nova Persei, 1901, were of about 3 days' period and of much greater amplitude (1·5 magnitude). During the oscillations of Nova Aquilæ the continuous spectrum was visible at maxima, but faded out at minima. Special notice is taken of an absorption band at λ4060 which appeared to shift towards the red at minima and towards the violet at maxima, with

some irregularities. Velocity relative to the sun, as deduced from H and K lines of Ca is — 19·9 km. ± 0·7 km. per sec. Measurements of line shift indicate a radial velocity of about 1440 km. from metallic lines and about 1360 km. from H lines alone. The discordance amounting to more than 1 Å. requires interpretation. The second series of H lines give a velocity of 2200 km. A plate gives enlarged reproductions of the portion of spectrum from λ3850 to λ5030 on June 9, 10, 14, 26 and July 4, 10, 17, and 30. The author wonders why in the evolution hypothesis millions of years should be required for the change of type undergone by Nova Aquilæ in 16 hours between the first two spectrograms. Full details are given of any remarkable features of the spectrograms, the last date mentioned being Nov. 10. **H. F. Newall.** (Roy. Astron. Soc., M.N. 79. pp. 31–35, Nov., 1918.)—The special point to which attention is drawn is the explanation of the sets of narrow absorption lines, as the superposition of two or three displaced spectra; the author had previously suggested this in the case of Nova Persei and Nova Geminorum, some of the peculiar appearances being of the nature of what he calls a "palisade" effect, as when looking from a distance at two sets of palings one behind the other. A good agreement is made for the region λ4000 to λ5000 on June 13 by superposing two displaced spectra of α Cygni; and on June 15 by three, but the former is much clearer. The author's conclusion is that his hypothesis is supported by the facts, even some which at first sight appear contradictory becoming reconciled after a closer scrutiny.
W. W. B.

276. *Nova Aquilæ.* **A. A. Rambaut.** (Roy. Astron. Soc., M.N., 79. pp. 108–120, Dec., 1918.)—Observations of Nova Aquilæ, including those of June 9 and 10, made by a member of the staff on military duty, from Hyde Park, cover the period to Dec. 10. Light-curves are given for this and for Nova Persei, 1901, and attention is drawn to similarities between the two. Omitting the first two days from max. brightness, each star shows a rapid fall of about $\frac{1}{5}$ mag. per day for 15 days, an average fall of about $\frac{1}{40}$ mag. per day for the next 69 days, and hardly any change for the next nearly 100 days. In each phase Nova Persei faded rather more quickly than Nova Aquilæ. Both stars showed fluctuations after the first phase, but those of Nova Aquilæ seem to have a definite period of 11 days and an amplitude of half a magnitude. **A. F. Miller.** (Roy. Astron. Soc. Canada, J. 12. pp. 479–493, Dec. 1918.)—Observations of magnitude, colour, position, character and visual spectrum of the nova, obtained at Toronto, June 10 to Oct. 25. The observer considers the nova at one period to be the reddest star he has ever seen and notes considerable fluctuations in relative brightness of different absorption bands. **H. P. Hollis.** (Roy. Astron. Soc., M.N. 79. pp. 36 37, Nov., 1918.)—With the Greenwich astrographic equatorial, the aperture being stopped down to 6 in., photographs of Nova Aquilæ and comparison stars with four different exposures were obtained on 46 nights from June 10 to Nov. 7. The formula, magnitude $= c - k\sqrt{(\text{diam.})}$ was used, and Schwartzschild's corrections for atmospheric absorption; 14 comparison stars were used as standards, and the resulting magnitudes vary from an estimated 0·00 on June 10 to 5·77 on Nov. 7, with definite fluctuations of uncertain period.
W. W. B.

LIGHT.

277. *Haidinger's Rings in Mica.* **T. K. Chinmayanandam.** (Roy. Soc., Proc. 95. pp. 176–189, Jan. 1, 1919.)—This paper gives a fuller study of Haidinger's rings in mica, some special features of which, due to double refraction, have been described by Rayleigh [Abs. 44 (1907)]. The principal results now obtained are as follows :—(1) The regions of minimum visibility in the field, due to the superposition of two independent sets of rings, lie along a series of curves which, in muscovite, are approximately hyperbolas. Rayleigh's observation that the lines of minimum visibility are crosses traversing the centre of the field is true only for particular thicknesses, and, even then, is not a complete description of the phenomena, as two series of hyperbolas are seen in addition to the cross. In phlogopite, the rings are indistinct along closed curves of oval shape. (2) The usual method of observing reflected systems of rings, using a plate of glass inclined at 45° to the plate under observation, is not satisfactory for the observation of Haidinger's rings in mica. The effects of a want of flatness, or other defect, in the mica plate, were considerably minimised by placing a diffusing screen close to the mica, with its surface parallel to it, and observing the rings through a hole cut in the centre of the screen. (3) In mica, as in all other crystals which cleave or which are cut perpendicular to one of the axes of optic symmetry, theoretical considerations indicate that the lines of minimum visibility in Haidinger's rings should be practically the same as the isochromatic lines observed in a plate of twice the thickness in convergent polarised light. This conclusion is in agreement with the observations. (4) In such crystals, if the angle between the optic axes is large, the rings are approximately two sets of ellipses, given respectively by the equations $a^2y^2 + c^2x^2 = \text{const.}$, $c^2y^2 + b^2x^2 = \text{const.}$; where a, b, c, are the principal velocities in the crystal. The major axes of one set are in the same direction as the minor axes of the other. These results are not far from the truth in the case of muscovite. (5) The ratios of the principal refractive indices in mica can be found with fair accuracy by observing the number of rings lying between successive lines of minimum visibility in the plane containing the optic axes, and in a perpendicular plane. A. W.

278. *Scattering of Light.* **W. J. de Haas.** (Ann. d. Physik, 57. 7. pp. 568-580, Dec. 20, 1918.)—A continuation and amplification of previous work on the scattering of light by systems of small apertures or opaque particles [Abs. 1155 (1918)]. A. W.

279. *Molecular Scattering of Radiation.* **J. Larmor.** (Phil. Mag. 37. pp. 161–163, Jan. 1919.)—A fundamental element in the theory of radiation is the principle first elucidated by Rayleigh, that when light is scattered by the particles of a fog or haze, or even by the molecules of the air, they act independently, without sensible mutual interference as regards the distribution of the energy. The condition necessary for this independence is that the disturbances (such as strain, velocity) must arrive from the scattering particles in phases which are entirely uncorrelated. This condition will be secured if the scattering particles are distributed at random, provided the intervals between adjacent ones are substantial fractions of the wave-length of the radiation that is being scattered; for then the phases of the scattered disturbances coming from adjacent particles will be uncorrelated. It holds good usually for particles of dust in the atmosphere, but in the case of a gas there are 10^6 molecules in a cubic wave-length, and in the case of a solid 10^9, giving differences of adjacent phases of the order of only 10^{-2} of the period in the former case and 10^{-3} in the latter. Even for a gaseous medium the question thus arises whether it is wrong to consider the distribution of the scattering molecules as based upon uniform spacing, but subject to uncorrelated deviations from this regularity which obey the law of statistics of gas-theory and amount at most to a few hundredths of the wave-length.

The author suggests that the principle advanced by Rayleigh is to be maintained, even to some extent for crystals (whose molecular regularity gives rise to practically no scattering), but its logical basis shifted. The molecules of the atmosphere are in thermal motion, with velocities in uncorrelated directions which are, at ordinary temperatures, of the order of 10^{-6} of that of the radiation. The wave-length of the radiation scattered from them will thus vary within a range of 10^{-6} of itself. If the phases of the scattered radiations are correlated at first, after traversing 10^6 wave-lengths, or 50 cm., they will have become fortuitous, and the energy effects thus additive. This consideration, if justified, would find the source of Rayleigh's principle in the uncorrelated thermal motions of the molecules. And since in a crystal thermal vibrations are contemplated about the mean positions of the molecules in the space-lattice, there ought to be some degree of scattering in traversing a crystal. [See Abs. 184 (1919).] A. W.

280. *Attempt to Explain the Michelson Interference Experiment.* **R. Birkeland.** (Phil. Mag. 37. pp. 150-156, Jan. 1919.)—The problem of determining the influence, if any, exercised by the earth's motion on optic phenomena on the earth's surface, is one of great theoretical interest and importance, and a vast amount of speculation and research has been devoted to the subject. The earth's mean orbital speed is $v = 30$ km./sec. and, compared with the light speed c, v is not negligible in all circumstances. All attempts to register effects of the order of magnitude of $v/c = 10^{-4}$ have failed. In 1881 A. A. Michelson devised his now famous experiment, by which it would be possible to discover effects of the order of $v^2/c^2 = 10^{-8}$. The expected effect was not registered. The experiment has been repeated with still greater accuracy, and at present most physicists feel sure that the effect does not really occur.

It had been possible to explain all previous experiments by the assumption of a stationary ether—a property of the ether which has been regarded as a necessary one by the majority of physicists. But to explain the experiment of Michelson it was necessary to introduce new hypotheses.

That which the author now puts forward he has delayed publishing for some years, but is now advised by some physicists to hold it back no longer on the ground that every new idea should be carefully examined. It is briefly as follows:—Imagine a point S on the earth's surface emitting light-rays in all directions. The earth and the light-source move in the direction SA at speed v. It is now assumed that in consequence of the earth's motion the ether all round the earth has become *anisotropic*, this anisotropy to diminish with increasing distance from the earth. The speed of light along SA being c, that along SA^1 at angle ϕ with SA is assumed to be given by (on account of the ether's anisotropy)

$$c_\phi = c\left\{1 - \tfrac{1}{2}(v^2/c^2)\sin^2\phi\right\}, \text{ or}$$
$$c_\phi^2 + (v\sin\phi)^2 = c^2.$$

The light is assumed to have the same frequency in all directions from S. It is to be noted that $v \sin \phi$ is the component of v perpendicular to the direction SA^1. According to this hypothesis the velocity of light does not differ greatly in different directions and the deviation might easily escape all notice. The ether is symmetrical about SA and the minimum speed of light would be perpendicular to SA and have the value $c(1 - v^2/2c^2)$. It is easily shown that this hypothesis would satisfy Michelson's results. E. H. B.

281. *Experimental Demonstration of Constancy of Velocity of Light from a Moving Source.* **Q. Majorana.** (Phil. Mag. 37. pp. 145–150, Jan., 1919.)—In a previous paper on the second postulate of relativity the author described an experimental arrangement by which it was demonstrated that light propagates itself with constant velocity, independently of the conditions of movement or rest of the mirror by which the light is reflected. At the end of that paper was mentioned the intention of studying experimentally the influence of the motion of the source on the speed of light, the object of the present note being to give the result of this second investigation.

For this purpose, mercury arc lamps were set in rapid rotation round a fixed point and the light examined by a Michelson interferometer. A peripheral speed of nearly 100 m. per sec. was obtained.

It is concluded that, under the conditions of the experiment and within the limits of experimental errors, the speed of light is not changed by motion of the source along the direction of propagation. [See Abs. 1405 (1914), 50, 927, and 1087 (1918).] E. H. B.

282. *Index of Refraction of Air for Wave-lengths from* λ2218 *to* λ9000. **W. F. Meggers** and **C. G. Peters.** (Bureau of Standards, Bull. 14. pp. 697–740 [Sci. Papers, No. 327], 1918.)—A survey of previous researches on the refraction of air shows that many investigators have worked either with white light or with one monochromatic radiation, and dispersion measurements have been limited to a small interval of the spectrum. No index measurements exist for waves longer than those corresponding to orange light, and in the ultra-violet the dispersion formulæ disagree by more than 10 % of the refractivity. Accordingly it was deemed advisable to measure the absolute indices of refraction of air for the entire spectral region accessible to photography. A Fabry and Perot interferometer was used, as this apparatus can be conveniently enclosed in a chamber in which the temperature and pressure of the air can be regulated as desired, and it also permits of simultaneous observations for a large number of different wave-lengths. Sections of the circular fringes, produced by various radiations from a source of light illuminating the parallel plates of the interferometer, were photographed either with a grating or a rock-salt prism spectrograph, first when the space between the plates was evacuated, and then when dry air at measured temperature and pressure was present. The index of refraction for a particular wave-length was obtained directly from measurements of the photographed interference fringes, which allowed the ratio of the lengths of this wave in vacuum and in air to be calculated. Observations were made at spectrum intervals of about 40 Å.U. from λ2200 to λ9000. Complete sets of observations were made on dry air at atmospheric pressure and at temperatures of 0°, 15°, and 30° C. These are quite closely represented by the following dispersion formulæ of the Cauchy form :—

$$(n-1)_0 \times 10^7 = 2875{\cdot}66 + 13{\cdot}412/(\lambda^2 \times 10^{-8}) + 0{\cdot}3777/(\lambda^4 \times 10^{-16})$$
$$(n-1)_{15} \times 10^7 = 2726{\cdot}43 + 12{\cdot}288/(\lambda^2 \times 10^{-8}) + 0{\cdot}3555/(\lambda^4 \times 10^{-16})$$
$$(n-1)_{30} \times 10^7 = 2589{\cdot}72 + 12{\cdot}259/(\lambda^2 \times 10^{-8}) + 0{\cdot}2576/(\lambda^4 \times 10^{-16})$$

These observations are used in the construction of a table giving the corrections which must be applied to wave-lengths measured in air whose density is not normal. A table of corrections to convert wave-lengths or frequencies measured in air to their values in a vacuum is also given. The coefficient of index variation with temperature was found from these measurements to be a function of the wave-length. For long waves this optical temperature coefficient is identical with the density temperature-coefficient 1/273, but as the ultra-violet absorption band is approached it increases rapidly, becoming 1/258 at λ2500. There seems to be no definite evidence of any strong absorption of infra-red light by dry air, and it is therefore possible to represent the optical dispersion of air by the first term of Sellmeier's formula quite satisfactorily. A. W.

283. *Correction of Optical Surfaces.* **F. Twyman.** (Astrophys. J. 48. pp. 256–258, Nov., 1918.)—A discussion of the relative advantages in the case of large lenses, of the method of correction previously described [Abs. 356 (1918)] and that proposed by Michelson [Abs. 1082 (1918)]. J. W. T. W.

284. *Rectangular Interferometer and the Horizontal Pendulum.* **C. Barus.** (Nat. Acad. Sc., Proc. 4. pp. 349–354, Nov., 1918.)—Describes the application of the rectangular interferometer with achromatic displacement fringes to the case of the horizontal pendulum, and gives a graph of the results obtained in the laboratory over a period of six weeks, the curve of inclination showing a qualitative resemblance to the temperature curve. The reason for the quantitative discrepancies is not fully clear. J. W. T. W.

285. *Micro-Metallography Illumination.* **H. M. Sayers.** (Engineering, 106. pp. 729–730, Dec. 27, 1918.)—The author deals with the general principles underlying the illumination of metallographic objects for microscopic examination with a view to avoiding "glare" and to getting the best possible results out of the objectives as regards definition and resolution. The virtual source of the light should be located at tube-length distance from the objective, measured along the path of the beam so that the light falling on the back lens of the objective should diverge as if it came from a source at that distance. The image of the source of light will be then focused on the object at the same time as the object is focused in the field. Maximum resolving power is obtained when the beam falling on the upper lens of the objective is approximately two-thirds of the diam. of the lens. If the actual light source at tube-length distance gives too small an image to fill a sufficient proportion of the field, a magnified real aerial image, of area great enough to fill the field, must be formed at that distance. To modify the brightness of the image a diaphragm either in the plane of the image or at the auxiliary condenser should be used, and not between the objective and the image of the source. For magnifications requiring objectives of shorter focus than ⅛-in., oil-immersion objectives should be employed. F. C. A. H. L.

286. *Seidel's Theory of Aberration of Lens Systems.* **A. E. Conrady.** (Roy. Astron. Soc., M.N. 79. pp. 60–66, Nov., 1918.)—Shows that Seidel's theory of the five forms of aberration in lens systems can be simply derived from the law of spherical aberration, namely, that the lateral deviation of a marginal ray at the paraxial focus is proportional to the third power of the aperture. [See original paper of Abs. 672 (1918).] J. W. T. W.

287. *Simplified Method of Tracing Rays through any Optical System.* **H. S. Jones.** (Observatory, No. 532. pp. 413–414, Nov., 1918.)

288. *Accuracy Attainable with Critical Angle Refractometers.* **F. Simeon.** (Phys. Soc., Proc. 30. pp. 190–199; Disc., 199–203, April, 1918.)—The three factors controlling the determination of a refractive index by means of a critical angle refractometer are, so far as the prism system is concerned, (1) the angle of the prism, (2) its refractive index, and (3) the angle of emergence of the critical ray from the second prism face. Expressions are obtained for the variation of the required refractive index with each of these factors separately and curves are given connecting these variations with the angle of emergence from the second prism face for various prism angles. AUTHOR.

289. *Notes on the Pulfrich Refractometer.* **J. Guild.** (Phys. Soc., Proc. 30. pp. 157–186; Disc., 186–189, April, 1918.)—Deals with points to be observed in the use and design of Pulfrich refractometers. A theoretical investigation of the various errors to which measurements are liable is included. AUTHOR.

290. *Fermat's Law.* **G. T. Walker, D. N. Mallik.** (Phil. Mag. 37. pp. 156–161, Jan., 1919.)—A discussion on the point as stated by D. N. Mallik [Abs. 1811 (1918)] that *optical energy is entirely kinetic*, and concerning which G. T. Walker expresses some doubt. To this it is replied by Mallik that the argument given is not now claimed to have proved that all energy is kinetic, but it is suggested that Fermat's law is capable of an interpretation which will yield this conclusion. It is trusted that the formal proof will be forthcoming in due course. E. H. B.

291. *Causes of Variation in the Watkins Factor for Different Developers.* **J. C. Kingdon.** (Phot. J. 58. pp. 270–276; Disc., 276–280, Dec., 1918.)—As no scientific explanation of the Watkins Factors appears to have been offered, the author undertook some experiments to ascertain whether variability of diffusion rate as amongst the various developers might be answerable for these phenomena. The idea was found to be untenable, the differences in the diffusion rates being too small to explain the wide variation in the factors for different developers. On the other hand, certain broad facts relating to diffusion were revealed, which, when taken in conjunction with the mechanical structure of the photographic film, permit the construction of a general theory to account for the observed facts on which the Watkins factorial method of development is based. The method of the experiments consists in the use of test-tubes filled with a gelatine jelly, and, when a developer is under examination, a graduated strip of bromide paper, suitably exposed, is enclosed in each tube to serve as an indicator. The tubes are placed over the solutions to be tested, the mouth of the tube dipping just below the surface of the liquid, so that the free surface of the jelly is in contact with the solution. Diffusion then proceeds continuously, the advance

of the solution along the column of jelly being marked by the blackening of the bromide paper. It is deduced that, as the long duration of time of appearance goes with a low Watkins Factor and short duration with a high factor, a developer whose time of appearance is of long duration must be at a relatively high molecular concentration in order to effect reduction, while one with short time of appearance will effect reduction at a lower strength. To complete this view a critical concentration of developers is assumed. Thus the critical concentration determines the time of appearance, because the time occupied in attaining the critical strength is in proportion to that strength—modified in a minor degree by the diffusion rate ; and the time of appearance determines the Watkins Factor. The total time of development necessary to secure a given density seems to depend on the velocity of penetration of the developer ; and, since the difference in the diffusion rates is small, the times of development must be nearly the same for all developers. The time of development is also modified to a small extent by critical concentration. Critical concentration will also be directly proportional to time of appearance, or nearly so, and in inverse proportion to the Watkins Factors. It is also assumed on evidence derived from the chemical constitutions of developers that each developer has a specific molecular stability which determines its critical concentration with regard to the development reaction. In the *discussion*, **Slade** criticised the authors' statement respecting critical concentration and **F. F. Renwick** that with respect to molecular stability. A. E. G.

292. *Colours of Colloids.* **W. D. Bancroft.** (J. Phys. Chem. 22. pp. 601–630, Dec., 1918.)—This paper gives a general discussion of the colours of two-phase systems, with special reference to the colours of plants and animal life. A. W.

293. *The Optical Behaviour of Water of Crystallisation.* **K[äthe] Brieger.** (Ann. d. Physik, 57. 4. pp. 287–320, Nov. 15, 1918. Extract from Dissertation, Breslau.)—The author has studied the reflecting power of nine isotropic alums of the type $(SO_4)_2M'''R \cdot 12H_2O$; of the two uniaxial crystal-hydrates, nickel sulphate, and nickel selenate ; and of the biaxial crystal-hydrates magnesium sulphate heptahydrate and zinc sulphate heptahydrate, zinc ammonium sulphate, nickel ammonium sulphate, nickel potassium sulphate, and nickel ammonium selenate ; and of the triclinic pentahydrates of copper sulphate and copper selenate. Thorium sulphate enneahydrate, sodium carbonate decahydrate, and the zeolite analcim were also investigated. The results obtained show that the H_2O group is arranged in the space lattice, in confirmation of the results obtained by Schaefer and Schubert. The position of proper oscillation of the water of crystallisation as compared with that of free water is, in all cases investigated, displaced in the direction of longer wave-lengths. Only in the case of analcim was a displacement towards shorter wave-lengths found. The influence of the chemical union of the water of crystallisation to the particular atom or atomic complex is, at the maximum of reflection of 3μ not so prominent as to lead to a final decision, by the method employed, in those cases where the constitution of the crystal-hydrate could not be experimentally tested. In comparing isomorphous hydrates having different acid radicals, a relative displacement of the water maximum is not found in the case of nickel sulphate and nickel selenate ; in the case of the sulphates and double sulphates the displacement—if appreciable at all—is so small that no conclusion could be drawn as to the

chemical union of the water. In the case of the alums, alone, does the water maximum lie at a markedly greater wave-length, but in these cases a doubling of the maximum is also found, as was observed also in the case of the water maximum at 6 μ. The occurrence of this has not yet been satisfactorily explained. The measurement of the reflecting power of analcim makes it appear hopeful that from further investigation of the doubly refracting zeolites an explanation of the rôle which water plays in the zeolites may be obtained. A. F.

294. *The Boundary Superposition Method for the Solution of Potential and Oscillation Problems.* **A. Landé.** (Ann. d. Physik, 57. 7. pp. 519–540, Dec. 20, 1918.)—According to Green's theorem, the observed light-oscillation at a point is regarded as the superposition of effects which proceed from any surface enclosing the point. For the solution of optical diffraction problems, Kirchhoff investigates these surfaces at the diffraction grating and assumes, approximately, that on the shade side of the grating absolute darkness exists while at the spaces the undisturbed light-oscillation is present and of the same phase and amplitude as possessed when the grating is absent. From the standpoint of exact theory the Kirchhoff approximation is to be regarded as the first term of an infinite series, whose subsequent terms lead stepwise to an improved solution. In the present paper such a series is established, whose first term is closely related to the Kirchhoff solution and whose further terms have been evolved by simple integrations from practical examples. There corresponds an analogous series for the similar electrostatic problem in which a conductor is placed in a given field and thereby disturbed. The exact solution is for the electrostatic as for the optical case determined as the solution of a boundary problem of the oscillation equation. Section 1 deals with the primary boundary value as an influence problem. Section 2 gives the asymptotic solution of the integral equation for the density of superposition. Section 3 contains a second development of the approximation method, and deals with the quality of the approximations. Section 4 gives the proof of the convergence of the potential equation. Section 5 evolves another approximation principle, and gives a comparison with the method of W. Ritz. Section 6 deals with the oscillation equation. In section 7 a comparison is made with the Kirchhoff approximation. In an appendix to the paper, examples of an influence problem and of a diffraction problem are given. H. H. Ho.

295. *On the Special Ultra-red Oscillations of Diatomic Crystals.* **M. Born.** (Phys. Zeits. 19. pp. 539–548, Dec. 15, 1918.)—In a recent communication [see Abs. 972 (1918)] the author has shown that the frequency of the special long-wave ultra-red oscillations of diatomic crystals can be calculated by the help of the lattice theory, and the order of magnitude correctly arrived at when the charge on the monovalent ion in the crystal is taken as great as that in electrolytes. Reference is made to Dehlinger's work [Abs. 1509 (1914)], who arrived at the same result in 1914 via another route. The present paper, however, is not superfluous, since Dehlinger had utilised the special hypotheses of the author with Karmán for the calculation of the lattice oscillations by which only the interactions between neighbouring atoms were treated. The author now shows that Dehlinger's formula follows entirely from the general results of the lattice theory and without any special assumptions. The numerical calculations of Dehlinger and the author are in agreement with respect to the order of magnitude of the calculated frequencies, but otherwise considerable differences remain. The Dehlinger formula contains an uncertainty which depends upon the question whether in the calculation of the electric force acting upon an atom the Lorentz force $eP/3$ is to be taken into account or not. The author now investigates this problem and shows that in the case of the ultra-red frequencies of the crystal, this Lorentz force may be ignored. The frequencies given, however, are continually too great, and Dehlinger's explanation is shown to be incorrect. The author believes that the deviations arise through the number of degrees of freedom assumed in the calculation being too small. The atoms were treated as mass points possessing 3 degrees of freedom, while in reality they are complex structures composed of a nucleus and a number of electrons. An electric field therefore not only displaces the atoms regarded as entities, but also rotates and deforms them. It may be possible, as Voigt proposes, to treat the atoms as rigid bodies (approximately), whereby rotations in the electric field can arise. In support of the author's view that the number of degrees of freedom is essential, he shows, on the assumption of the atoms being treated as mass points, that for diatomic regular lattices another relation holds, which, while leading to correct orders of magnitude, is nevertheless insufficient. Finally, from the presentation that the atoms are nuclei surrounded by electronic clouds, the author establishes that the deviations from Dehlinger's formula are to be expected. Section 1 deals with the Lorentz force $eP/3$, section 2 with the relationships between the constants of diatomic regular lattices, and section 3 with the influence of electrons upon the refractive index in the ultra-red. H. H. Ho.

296. *Wave-length Measurements in the Spectrum of Neon.* **K. Burns, W. F. Meggers,** and **P. W. Merrill.** (Bureau of Standards, Bull. 14. pp. 765–775 [Sci. Papers No. 329], 1918.)—The wave-lengths of 55 lines in the neon spectrum have been measured by means of the interferometer. These lines lie in the region λ3369 to λ8495. The strong lines in the visible region have been observed with great accuracy, the probable error being one part in several millions, or less than one-tenth the width of the line. These strong lines were observed by means of three different pairs of interferometer plates which were each used on several interferometers. The ultra-violet lines and all the strong lines in the visible spectrum were compared directly with the fundamental standard λ6438. Some of the deep-red and infra-red lines were compared with well-determined lines in the visible neon spectrum. In addition to the above, 189 faint lines in the visible and infra-red neon spectrum have been measured by means of a concave grating. The probable error of these grating measurements is one or two hundredths of an Å.U. The region covered by the grating observations extends from λ5343 to λ8473. The constant differences discovered by Watson are found to hold with remarkable exactness in the case of lines which are strong enough to be measured with the highest accuracy. In fact, the differences are exactly constant within the limits set by the accuracy of the wave-length measurements. A. W.

297. *Ionisation and Resonance Potentials for Electrons in Vapours of Magnesium and Thallium.* **P. D. Foote** and **F. L. Mohler.** (Phil. Mag. 37. pp. 33–50, Jan., 1919.)—The ionisation and resonance potentials for electrons in vapours of Mg and Tl have been measured, using the method of Franck and Hertz as modified by Tate. The experimentally determined values for Mg vapour were 2·65 volts for resonance potential and 7·75 volts for ionisation

potential. The corresponding theoretical values on the basis of the quantum relation $h\nu = eV$ are 2·70 volts and 7·61 volts respectively. The experimentally determined values for Tl vapour were 1·07 volts for resonance potential and 7·3 volts for ionisation potential. The theoretical value for ionisation potential is not known. For Mg the ionisation potential is determined by the limit of the combination series $1{\cdot}5\,S - mp_2$, and the resonance potential by the first line of this series, $m = 2$. For Tl the resonance potential is determined by the shorter wave-length member of the first term of the principal series of doublets. No known series in Tl has a convergence frequency greater than 49,263. The observed ionisation potential for Tl suggests the presence of an undiscovered series of single lines converging at $\nu = 1{\cdot}5S = 57{,}000$ to 60,000. The present work offers evidence that the single-line spectra of Mg and Tl are $\lambda = 4571$ and $\lambda = 11{,}513$ A.U. respectively. The general behaviour of the metals as regards ionisation and resonance potentials appears to be identical for metals in the same group of the periodic table. In the case of Tl the component of the doublet having the higher frequency determines the value of the energy-quantum absorbed by the atom. This fact suggests either the possibility of separate excitation of the components of a doublet by electronic impact or a behaviour of Tl vapour, thus excited, analogous to the emission of characteristic X-rays for which the K-group does not appear until the energy of the impacting electrons is greater than that corresponding to K_γ. From work carried out mainly at the Bureau of Standards the authors have obtained a value of Planck's constant h by the method of ionisation and resonance potentials. Using 13 determinations on 7 different metals, each determination a mean of several experiments, the final value of $h = 6{\cdot}55 \times 10^{-27}$ erg sec. was obtained, in excellent agreement with recent determinations by other methods. The question of photoelectric sensibility of metallic vapours is briefly discussed, and several recent papers upon the subject of ionisation and resonance potentials are considered from a critical standpoint. [See Abs. 1308 (1917) and 193 (1918).] A. W.

298. *Light Emission from Gases and Gas Mixtures.* **L. Hamburger.** (Zeits. Wiss. Phot. 18. 1–2. pp. 1–44, Aug., 1918. Dissertation, Delft, 1917. Engineering, 107. pp. 215–216, Feb., 14, 1919. Abstract.)—Experiments were made in the Philips glow-lamp works, Eindhoven, Netherlands, with direct current of relatively high density at gas pressures of about 1 mm.; the intensities of the lines of the spectra were measured by the photographic method of Holst and Hamburger [Abs. 778 (1918)]. The general results have been noticed in Abs. 793 (1918); two plates of photographs are reproduced. As regards ammonia, the author obtains evidence of an absorption band at 3360 Å. which is absent from the spectra of nitrogen, of hydrogen, and of mixtures of these gases with other indifferent gases, and which may hence be ascribed to ammonia. In cooled capillary tubes fairly satisfactory yields of synthetic ammonia were realised by passing currents of 12 amps./cm.^{2} through mixtures of nitrogen and hydrogen. H. B.

299. *The Theory of Triboluminescence.* **H. Schmidt.** (Phys. Zeits. 19. pp. 399–401, Sept, 15, 1918.)—A criticism, mainly destructive, of Imhof's theory [Abs. 1279 (1917).] L. H. W.

300. *An Absolute Determination of Crystal Structure and Properties, using Bohr's Atom-model as Basis.* **M. Born** and **A. Landé.** (Preuss. Akad. Wiss. Berlin, Ber. 45. pp. 1048–1068, 1918.)—A mathematical paper divided into the following sections: (1) The potential of two electron-rings. (2) The distance between atoms in molecules. (3) The elementary-spacing for a class of regular crystals. (4) The potential of the cubical space-lattice. (5) The potential of (−1)th order (according to Madelung). (6) The potential of the (−5)th order; Comparison with experimental observations.

A. B. W.

301. *Investigations on the Continuous X-ray Spectrum; Influence of the Antikathode Metal.* **J. E. Lilienfeld.** (Phys. Zeits. 19. pp. 514–516, Dec. 1, 1918.)—A direct comparison is made between the X-ray spectra obtained when antikathodes of Pt-Ir and of Mo are employed. Photographs, reproduced in the paper, show clearly that the "general" intensity distribution in the two spectra is the same, the only differences being due to the characteristic lines of the elements of the antikathodes. The author discusses his results in relation to those of other investigators, particularly Hull and Rice, and Rutherford, Barnes, and Richardson. A. B. W.

302. *Note on the Relation between X-ray Spectra.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 524–527, Dec., 1918.)—Employing the Kossel and Malmer relations—

$$\left.\begin{aligned} L_{\alpha_1} &= K_{\beta_1} - K_{\alpha_1} \quad \text{..............} \quad (1)\\ M_{\beta} &= L_{\gamma_1} - L_{\beta_1} \quad \text{..............} \quad (2)\\ M_{\gamma_1} &= L_{\gamma_2} - L_{\beta_2} \quad \text{..............} \quad (3)\end{aligned}\right.$$

the author obtains

$$L_{\beta_2} - L_{\alpha_1} = L_{\gamma_1} - L_{\beta_2} = L_{\gamma_2} - L_{\beta_3} - \Delta \quad \text{..............} \quad (4)$$

and

$$L_{\beta_1} - L_{\alpha_2} = K_{\beta_1} - K_{\alpha_1} \quad \text{..............} \quad (5)$$

From K_{α}, L_{α_1} etc., can be deduced the frequencies of Siegbahn's series spectra, whilst Δ is a constant.

The author uses the experimental values of Dershen and of Siegbahn in verifying the relations (4) and (5). A. B. W.

303. *The Continuous X-ray Spectrum.* **A. Müller.** (Phys. Zeits. 19. pp. 489–490, Nov. 15, 1918.)—According to Einstein's relation $eV = hc/\lambda$, there exists in the continuous X-ray spectrum a limiting wave-length λ which is independent of the material of the antikathode. The present paper gives the results of an experimental investigation of this deduction from Einstein's equation. The antikathodes used were the following:—Copper, silver, Cu/Ag, Ag/Pb, lead. Einstein's law is verified, within a few per cent., over a range of voltage of 14 to 28 kilovolts. Planck's constant, the mean of all observations, is given as

$$h = 6{\cdot}58 \times 10^{-27} \pm 0{\cdot}07 \times 10^{-27} \text{ erg sec.}$$

A. B. W.

304. *Structure of Carborundum determined by X-rays.* **C. L. Burdick** and **E. A. Owen.** (Am. Chem. Soc., J. 40. pp. 1749–1759, Dec., 1918.)—The authors have made careful measurements of the angles of reflection of palladium X-rays from the principal planes of a crystal of carborundum and measurements of the intensities of the different orders have been made and interpreted. The results show that the silicon atoms and carbon atoms in carborundum are each arranged on face-centred rhombohedral lattices, very nearly cubic ($\alpha = 89^\circ\ 56{\cdot}6'$) and displaced with respect to one another along the hexagonal axis a distance equal to 0·36 of the basal plane (111) spacing. The elementary tetrahedron of carborundum is therefore very similar to that of diamond, the difference consisting in a slight shortening of the vertical axis (0·15 %) and a displacement of the atoms of carbon from the centres of the tetrahedron (0·25 of the altitude in the case of the diamond) to a position slightly less distant from the apex (0·36 of the altitude in the case of carborundum).

From the values of the distances between the atom planes as derived from the X-ray measurements the density of carborundum is calculated to 3·11, whereas the observed value is 3·123. A. B. W.

305. *Theory of X-ray Spectra.* **F. Reiche** and **A. Smekal.** (Ann. d. Physik, 57. 2. pp. 124–144, Oct. 15, 1918.)—Mathematical; does not permit of a short Abstract. A. B. W.

RADIO-ACTIVITY.

306. *Number of α-particles emitted by Radium.* **F. Hess** and **R. W. Lawson.** (Archives des Sciences, 46. pp. 330–331, Dec., 1918. Paper read before the Soc. suisse de Physique, Sept., 1918.)—The only direct experimental determination of this constant is that due to Rutherford and Geiger (1908) which gave a value $3{\cdot}4 \times 10^{10}$ or $3{\cdot}5 \times 10^{10}$ when corrected to the international radium standard. On theoretical grounds the authors considered that a re-determination of this constant was advisable. The method employed was the same in principle as the ionisation by collision method of Rutherford and Geiger. "Counts" were made in air, CO_2, and in mixtures of air and CO_2—using the string electrometer of Elster and Geitel. They found that in air the β- and γ-rays were as effective as the α-particles; in CO_2 and in mixtures of CO_2 and air (containing not less than 54 % CO_2) only the α-particles produced ionisation by collision. Thus in the exact determination of the number of α-particles emitted from RaC, in the presence of β- and γ-rays, a mixture of 54 % CO_2 and 46 % air was employed. The conditions of the experiment were varied as much as possible and control experiments carried out frequently. 268 determinations, each count lasting not less than 10 minutes, gave a value $Z = (3{\cdot}72 \pm 0{\cdot}02) \times 10^{10}$ for the number of α-particles emitted per sec. per gm. of radium.

The value of Z determined from measurements of the heating effects and ranges of α-particles of radium gives

$$Z = 3{\cdot}88 \times 10^{10} \text{ (for a range } r_{15^\circ} = 3{\cdot}30 \text{ cm.) and}$$
$$Z = 3{\cdot}78 \times 10^{1} \text{ (,, ,, } r_{15^\circ} = 3{\cdot}44 \text{ cm.)}$$

Reciprocally, the value $Z = 3{\cdot}72 \times 10^{10}$, given above, furnishes a determination of the velocity and of the range of the α-particles of radium. These values are $v = 1{\cdot}59 \times 10^{9}$ cm./sec. and $r_{-15^\circ} = 3{\cdot}52$ cm.—assuming a rate of heat emission of 25·2 cals. per hour.

The authors use their value of Z to calculate the period of radium, $Z = \lambda N$, whence $\lambda = 1{\cdot}39 \times 10^{-11}\ \text{sec.}^{-1} = 4{\cdot}38 \times 10^{-4}\ \text{years}^{-1}$, giving a period of half-transformation T = 1580 years. A. B. W.

307. *Reflection of α-particles in Long Tubes.* **R. W. Lawson** and **V. F. Hess.** (Archives des Sciences, 46. pp. 331–333, Dec., 1918. Paper read before the Soc. suisse de Physique, Sept., 1918.)—If α-rays fall on a metal plate or on a glass surface at a given angle of incidence, a certain proportion will be re-emitted on the incident side, simulating a kind of "reflection" of α-rays. In making accurate determinations of the number of α-particles emitted from 1 gm. of Ra [see preceding Abs.] the authors used certain peculiarly constructed screens with circular openings to eliminate this source of disturbance. After accomplishing this, they carried out a series of experiments, now described, to examine this so-called reflection phenomenon. "Reflection" took place inside a glass tube 8 cm. in diam., the α-particles being counted by the method referred to in the foregoing Abstract. It was found that the calculated number of α-particles emitted per min. by 1 gm. equiv. of RaC and arriving at the "counter" was $1·6 \times 10^4$—in good agreement with the mean value $1·5 \times 10^4$ obtained by direct measurement. Only 10^{-8} of the total number of α-particles emitted are "reflected" and arrive at the counting apparatus. A. B. W.

308. *Refractive Index and Solubilities of the Nitrates of Lead Isotopes.* **T. W. Richards** and **W. C. Schumb.** (Nat. Acad. Sci., Proc. 4. pp. 386–387, Dec., 1918. Am. Chem. Soc., J. 40. pp. 1403–1409, Sept., 1918.)—Using an Abbe-Zeiss total-reflecting crystal refractometer, the refractive index of common lead nitrate at 20° was found to be 1·7815 and that of uranio-lead nitrate to be 1·7814—each value being the mean of many concordant observations. Thus the difference in atomic weight shown by the two specimens of lead (at. wt. respectively 207·20 and 206·41) has no appreciable effect on the refractive index of the salt.

The purified crystals used in the above investigation were next examined carefully as regards solubility. Four determinations with ordinary lead nitrate gave an average solubility of 37·342 gm. of nitrate in 100 gm. solution, and more determinations with uranio-lead nitrate gave an average value of 37·280 gm. per 100 gm. solution. These results are precisely proportional to the different molecular weights of the two samples of nitrate.

The above results confirm earlier work upon other properties of the lead isotopes. A. B. W.

309. *Absorption of Radium γ-rays.* **K. W. F. Kohlrausch.** (Akad. Wiss. Wien., Ber. 126. 2a. pp. 683–704, 1917. Comm. No. 98 from the Inst. f. Radiumforschung.)—The results of this investigation are indicated in the following table, where K_1, K_2, K_3, are the three components of the complex γ-rays from radium:—

Absorber.	Absorption Coefficients μ_1, μ_2, and μ_3.		
	K_1.	K_2.	K_3.
Lead	0·545	1·4	4·6
Zinc	0·327	0·57	1·44
Iron	0·356	0·63	3·00
Aluminium ...	0·127	0·23	0·57

The ratio of the energies, measured by ionisation currents, is, for these three components $K_3 : K_2 : K_1 = 1 : 6 : 8$. The absorption measurements show that the influence of secondary radiation is extremely important. A. B. W.

310. *The Hard Secondary γ-rays from Radium.* **K. W. F. Kohlrausch.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 705–720, 1917. Comm. No. 99 from the Inst. f. Radiumforschung.)—In a previous communication [see preceding Abs.] the author made a careful series of measurements of the absorption of the γ-rays of radium in various substances. In these experiments the importance of secondary radiation was indicated. The present paper deals with this secondary radiation, which is shown to have a high penetrating power.

When the radium γ-rays pass through matter a very hard type of secondary radiation ($\mu_{Pb} = 0{\cdot}545$ cm.$^{-1}$) is produced. The author compares the observed total energy of the secondary radiation with the calculated values for varying thickness of screen. The observations are in good agreement with theory. A. B. W.

311. *Absorption of γ-rays from Radium.* **K. W. F. Kohlrausch.** (Akad. Wiss. Wien., Ber. 126. 2a. pp. 887–913, 1917. Comm. No. 102 from the Inst. f. Radiumforschung.)—This paper is a continuation of others on the same subject [see Abs. 780 (1918) and two preceding Abs.]; it gives the results of an extensive series of measurements of the absorption coefficients of radium γ-rays in different substances. If data are required the original paper should be consulted. A. B. W.

312. *The Gamma-ray Activity of ThD.* **H. N. McCoy** and **G. H. Cartledge**. (Am. Chem. Soc., J. 41. pp. 50–53, Jan., 1919.)—Eve [Abs. 1575 (1906)] and McCoy and Henderson [Abs. 55 (1919)] have independently determined the quantity of thorium, in equilibrium with its products, which has the same γ-activity as 1 gm. of Ra in equilibrium. Their results were $6{\cdot}9 \times 10^6$ gm. and $6{\cdot}85 \times 10^6$ gm. respectively. Furthermore, McCoy and Henderson have determined the ratio Ms : Th, the mesothorium being expressed in terms of the weight of Ra giving the same γ-activity. The value found for this ratio is given as $0{\cdot}52 \times 10^{-7}$. The reciprocal ratio $19{\cdot}0 \times 10^6$ is the number of gm. of thorium necessary to furnish 1 gm. mesothorium. Therefore mesothorium accounts for only 36·3 % of the total γ-activity of the thorium series, although ThD is the only other thorium product which emits a γ-radiation.

The authors therefore considered it a matter of importance to determine independently the ThD/Th ratio in order to ascertain whether the combined mesothorium and ThD would give the total γ-activity.

Two different methods of determining the ratio ThD/Th were employed, a mean value of all determinations being $0{\cdot}956 \times 10^{-7}$.

Taking McCoy and Henderson's value for the thorium equivalent of 1 gm. Ra, $8{\cdot}85 \times 6$, we get $1{\cdot}46 \times 10^{-7}$ gm. as the weight of Ra equal to 1 gm. of Th in equilibrium. Combining $0{\cdot}52 \times 10^{-7}$ (McCoy and Henderson's Ms/Th ratio) with $0{\cdot}96 \times 10^{-7}$ (the ThD/Th ratio here reported), we get $1{\cdot}48 \times 10^{-7}$ gm. as the radium equivalent of the γ-products of Th determined separately.

This figure agrees well, within experimental error, with that for the total γ-activity of the thorium minerals. A. B. W.

HEAT.

313. *Thermal Conductivity of Neon.* **S. Weber.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 342–356, 1919. Suppl. No. 42b to the Comm. from the Phys. Lab., Leiden.)—Describes experiments, by a modification of Goldschmidt's method [Abs. 1169 (1911)] of the thermal conductivity of neon at various temperatures. Subsidiary experiments showed that it was important to allow for the conduction of heat by the leads from the ends of the hot wires. The values obtained were based on Knudsen's and v. Smoluchowski's investigation of the temperature-drop between the surface of the hot body and the layer of gas adjacent to it. The values of conductivity found were :—

T.	K'.	K' (calc. S).	K' (calc. $\beta = 5$).
273·09 + 105·81	0·0001344	0·0001344	0·0001364
273·09	1087	1087	1087
273·09 — 74·37	0879	0869	0869
273·09 — 181·43	0499	0468	0505

where the second column gives the observed conductivity, the third column that found from Sutherland's formula, and the fourth column the values found from the formula $K/K_0 = (T/T_0)^{0·5+1/\beta}$, using the value $\beta = 5$.

J. W. T. W.

314. *The Specific Heat of Platinum at High Temperatures.* **W. P. White.** (Phys. Rev. 12. pp. 436–441, Dec., 1918.)—Making use of the apparatus and method previously described [Abs. 196 (1919)], the author has determined the specific heat of very pure Pt from 100° to 1300°. The accuracy obtained is estimated to be better than 0·3 per mille. The following values were obtained :—

20°–100°, 0·03186 ; 20°–300°, 0·03271 ; 20°–500°, 0·03333 ; 20°–700°, 0·03399 ; 20°–900°, 0·03460 ; 20°–1100°, 0·03523 ; 20°–1300°, 0·03592.

The true specific heat at 300° and above is given by the expression $0·031686 + 0·0000364\theta$. At 100° there is a very satisfactory agreement with the results obtained by Gaede, and at higher temperatures with those of Plato, Corbino, Magnus, and Fabaro. Most published results below 100° appear to be 1 % or more too high. The atomic heat of Pt at constant volume is, from 100° up, above the value, 5·96, indicated by Dulong and Petit's law, and by the accepted kinetic theories of the solid state, and increases also regularly to 1300°, and probably beyond that. A. F.

315. *Pyrometers and Pyrometry.* (Faraday Soc., Trans. 13. pp. 205–372, June, 1918.)—Besides an introductory address by **R. Glazebrook** and a contribution from **R. Hadfield**, the following Papers are included in this symposium :—"Production and measurement of high temperature," by **E. F. Northrup** ; "Pyrometer standardisation," by **E. Griffiths** and **F. H. Schofield** ; "Radiation pyrometry," by **P. D. Foote** ; "Automatic control of high temperatures," by **R. P. Brown** ; "Advantage of burying the cold junction of a thermo-couple," by **R. S. Whipple** ; "Pyrometry applied to hardening of high-speed steels," by **J. O. Arnold** ; "Optical pyrometry in non-ferrous metallurgy," by **F. G. Donnan** ; "Temperature determination of liquid steel," by **C. Johns** ; "Pyrometry from the standpoint of ferrous metallurgy," by **W. H. Hatfield** ; "Optical pyrometry in steel works practice," by **J. N. Greenwood**. L. H. W.

316. *Empirical Formula for the Calculation of the Specific Heat of Water.* **J. Narbutt.** (Phys. Zeits. 19. pp. 513–514, Dec. 1, 1918.)—In the course of an extended calorimetric investigation for the purpose of standardising Nernst's copper calorimeter, the author found relatively slight agreement between the data of various observers for the specific heat of water at higher temperatures. During recent years many experimental investigations by varying methods have been made on the specific heat of water, which have furnished the author with material for an empirical formula giving the average specific heat from 0° to 100° C. The authors quoted are Lüdin, Dieterici, Bousfield, Callendar, Barnes, and Cooke, and from their data, which are treated as of equal accuracy, a formula containing four constants has been derived via the method of least squares, namely :

$$C_0^t = 1{\cdot}00733 - 0{\cdot}0_3 3708t + 0{\cdot}0_5 5615t_2 - 0{\cdot}0_7 2388t^3.$$

For this purpose C_{15} has been made unity. A table of the data taken from the above authors is given and briefly discussed in connection with the formulæ deduced by them. A further modification of the formula to :

$$C^t = 1{\cdot}00733 - 0{\cdot}0_3 7416t + 0{\cdot}0_4 16845t^2 - 0{\cdot}0_7 9552t^3,$$

has been found to be almost in exact agreement with Jaeger and Steinwehr's recent work (1915). A comparative table of results is given. H. H. Ho.

317. *The Conditions of Calorimetric Precision.* **W. P. White.** (Am. Chem. Soc., J. 40. pp. 1872–1886, Dec., 1918.)—The paper deals with the various factors which affect the accuracy of the results in calorimetric measurements and discusses the general rules or principles of such work. It is pointed out that in a calibrated calorimeter practically all the errors come in temperature measurement, and the most, though often not the greatest of these come in the "cooling correction," that is, the determination of the effect of thermal leakage between calorimeter and environment. This leakage effect is equal to $K\phi T$, where T is time, ϕ the thermal head (difference of calorimeter and environment temperature) for the experimental period, and K the thermal leakiness, or leakage modulus, of the calorimeter. If any of these three quantities is diminished its own errors are usually little changed, but the errors of the others now have a smaller multiplier. Thus : (1) By diminishing K (as by means of a vacuum) the effect of errors in ϕ is diminished which lie (*a*) in getting the environing (jacket) temperature sufficiently uniform, (*b*) in getting the calorimeter temperature uniform without too great an error from heat of stirring. This latter difficulty grows in importance as measurements become more delicate. Usually, errors in ϕ may easily be made negligible, and great diminution of K is then of secondary importance. (2) A diminution in ϕ, as by the adiabatic method, or by methods similar to that of Rumford, diminishes the effect of errors in K, such as variation from Newton's law. But owing to the peculiarities of the computation, it does not much affect the main error connected with K, that is, in determining K by means of the cooling rate, unless methods can be used which presuppose an accurate knowledge of the heat of stirring. (3) Lags have a law of their own ; they vary with K, are independent of T and ϕ, and can usually be made to cause little or no error. (4) The stirring introduces a possible error from irregular heat production, due to irregular steel. Since the heat varies as the cube of the speed, the error tends to vary as the cube of the efficiency of stirring, and thus may become very important in delicate measurements. E. G.

318. *Calorimetric Methods and Devices.* **W. P. White.** (Am. Chem. Soc. J. 40. pp. 1887–1898, Dec., 1918.)—In this paper the general rules for calorimetric precision given in a previous paper [preceding Abs.], are applied to certain structures, namely, jacket covers and stirrers; and to the following special devices: vacuum-jacketed vessels, the adiabatic method, aneroid or dry calorimeters, double or differential calorimeters, and measured-shield calorimeters. (1) Vacuum-jacketed vessels are mainly useful either in relatively crude or in very exacting work. They are convenient and simple in crude work, but cause difficulty and complication if the work to be done demands more elaborate arrangements. (2) The adiabatic method does not diminish either of the two main sources of thermal leakage error, but has numerous advantages. (3) The Pfaundler twin calorimeter method still enables high precision to be attained with relatively simple apparatus, but is most successful when applied to liquids, and to the comparing of two things which are nearly alike. (4) Aneroid calorimeters work quicker, and within limits also more accurately, the smaller they are. (5) The *measured shield method*, where a convection shield supplied with thermo-couples is used, diminishes very greatly the difficulties of thermal head measurement and stirring, which are among the greatest in work of precision, and is more convenient than glass vessels. E. G.

319. *Theory of the Characteristic Curves of the Homogeneous State and its Connection with the Thermodynamics of Adiabatic Expansions.* **L. Schames.** (Ann. d. Physik, 57. 5. pp. 321–346, Nov. 26, 1918.)—Section 1 of this paper discusses its objective and gives a survey of the subject-matter involved. Reference is first made to an earlier communication in 1915, in which the investigation of the characteristic curves of the homogeneous state was initiated; now a more comprehensive theoretical treatment is given. While the thermodynamic basis of the throttle expansion is known, that of free expansion is here newly evolved in complete analogy with the former. By introducing the thermodynamic relationships into the purely thermodynamic equation of state, a remarkably simple form of this is obtained, which is very suitable for practical application when the specific heats in the Avogadro state together with the throttle and free expansion curves are known. On the other hand, by integration according to 1/T, two forms of the equation of state are obtained from the thermodynamic relationships, which lead to two entirely new characteristic curves (species II). Two other curves of somewhat minor importance will also be referred to (species III). In section 2 rigid theoretical hypotheses are developed with respect to the starting, crossing, and end points of the characteristic curves. General definition is given to characteristic curves of all species, and special definition to those of species I, namely, such in which the three component laws of the perfect gas (Boyle, Gay-Lussac, and Joule) are embodied. Section 3 deals with theoretical deductions from the characteristic curves of species I, and section 4 with their empirical results. The latter are found to be in agreement with the form. From Bridgman's measurements it is concluded that the characteristic curve V of species I exists for all substances. In section 5 the already established thermodynamics of the throttle expansion, which is connected with the Gay-Lussac curves, is newly derived by means of a purely geometrical method. In section 6 the thermodynamics of free adiabatic expansion is derived for the first time and by a similar method to that employed in section 5. The relationship to the Joule curves is shown. Section 7 is concerned with the development of the purely thermodynamic equation of state, which is obtained in a remarkably simple form by means of the derived thermodynamic relations. In this form it is exceedingly suitable for the construction of a p. T-diagram with throttle and free expansion curves, as also for volume estimation and differential and integral cooling effects. Section 9 considers the basis of characteristic curves of species II. By integration according to 1/T, two further forms of the equation of state are obtained from the thermodynamic relations, which lead to two new curves of this species. It is shown that characteristic curve VII cannot be identical with curve II of species I, a possibility held by Jakob. Finally, in section 10, two characteristic curves of species III are discussed; section 11 is a tabular survey of all the characteristic curves. It is shown that by means of this investigation important conclusions are to be drawn with respect to the general problem of state, especially as regards the behaviour of the thermodynamically defined attraction magnitude and the second virial coefficients. The latter important result, namely, zero for $T = \infty$ when the Joule point is finite, the author hopes to discuss in the near future by means of experimental data as also from theoretical molecular considerations. H. H. Ho.

320. *Calorimetric Lag.* **W. P. White.** (Am. Chem. Soc., J. 40. pp. 1858–1872, Dec., 1918.)—This paper makes an addition to the mathematical treatment of lag effects in calorimetry, and also derives therefrom several suggestions for advantageous experimental arrangements. The lag effects of bodies external to calorimeters, although complicated in expression, are found to follow the same general laws as the simpler lag effects already described. More carefully stated than previously, these effects prove to be three: (1) Equivalent to a change in the heat capacity of the calorimeter; this can be eliminated if a calorimeter is directly calibrated. (2) Much smaller than the first, depending on the amount of thermal leakage; this can be avoided, if necessary, by using the adiabatic method. (3) Dependent on the jacket temperature, which disappears for constant jacket temperature. This one causes the calorimeter to have a different effective heat capacity when used adiabatically. Of two errors peculiar to the aneroid calorimeter one comes from improper distribution of the thermo-junctions which measure the surface temperatures. This error becomes zero if the surface temperature distribution does not change from one experiment to another. The other special source of error is inconstancy of final temperatures due to inconstancy of final jacket temperature. On account of the lag effect the effective heat capacity of a shield midway between calorimeter and jacket is only one-fourth the actual capacity, and with due regard to the possibility of change such shields may often, with great profit, be used to reduce the thermal leakage. Used as a cover such a shield has a specially small error, and offers a particularly easy method of dealing with evaporation. Ordinary non-metallic covers, on account both of their lag and their heat capacity, are very undesirable. Although a normal lag effect characterises even thick and heterogeneous packings around a calorimeter, the loss of time due to the lag is sufficient objection to the practical use of anything which is not either very small or in very close thermal connection with calorimeter or jacket. E. G.

SOUND.

321. *Vibrations of Bowed Strings and Instruments of the Violin Family.* **C. V. Raman.** (Indian Assoc. for Cultivation of Science, Bull. No. 15. pp. 1–158, 1918.)—In this lengthy memoir, which is but the first portion of Part I of the whole treatment, the author after a brief introduction lays the foundation of a mechanical theory of bowed strings and the associated parts of the musical instrument on which they occur. The equations of motion are written and solved for the case of a periodic transverse force applied by the bow at a given position. The equations of motion of the bridge are next written and dealt with. The modus operandi of the bow is examined and a simplified kinematical theory of the bowed string is based upon it. This leads to a number of types of vibration: two-step zig-zag, three-step, four-step, etc., motions appearing in the corresponding graphs.

The effect of the violin *mute* which, by loading the bridge, enfeebles and veils the tone of the instrument is investigated. For this purpose loads were placed at various positions on the bridge and simultaneous photographic curves obtained of the bridge and each of the strings in turn. The very fine and instructive results so obtained are shown in full-page plates. Photographic reproductions are also given of simultaneous vibration curves of belly and string of a violoncello at the "wolf-note" pitch, showing cyclical changes of amplitude. Other points dealt with are the effects of the variation of pressure and velocity of bowing, the relation between pressure and speed, the width of the bowed place, the yielding of the bridge, and the vibrations obtained from a 'cello by plucking the strings.

The memoir, which should be consulted in the original by all those interested, contains 28 text figures and 26 excellent full-page photographic reproductions. E. H. B.

322. *Theory of Double Resonator.* **Rayleigh.** (Phil. Mag. 36. pp. 231–234, Sept., 1918.)—In his *Theory of Sound* the author has considered the case of a *double* resonator, where two reservoirs of volumes S, S′ communicate with each other and with the external atmosphere by narrow passages or necks. If SS′ were treated as a single reservoir and the usual formula applied, an erroneous result would follow. For that formula is founded on the assumption that within the reservoir the inertia of the air may be left out of account, whereas it is evident that the energy of the motion through the connecting passage may be as great as through the other two. However, an investigation on the same general plan meets the case perfectly. Denoting by X_1, X_2, X_3 the total volumes of fluid transferred through the three passages, we have for the kinetic energy the expression $T = \frac{1}{2}\rho[1/c_1 . (dX_1/dt)^2 + 1/c_2 (dX_2/dt)^2 + 1/c_3 . (dX_3/dt)^2]$...(1), where ρ is the density of the fluid, while c_1, c_2, c_3 may be interpreted as the *electrical conductivities* of the passages. Thus for a long cylindrical neck of radius R and length L we should have $c = \pi R^2/L$. Again the potential energy is $V = \frac{1}{2}\rho a^2[(X_2 - X_1)^2/S + (X_3 - X_2)^2/S']$...(2), where a is the speed of sound in the fluid concerned. By application of Lagrange's method the differential equations of motion are then found, and on putting all the X's proportional to e^{pt}, equations in p^2 are found for the various cases. Thus the general equation is $p^4/a^4 + p^2/a^2 . [(c_1 + c_2)/S + (c_2 + c_3)/S'] + 1/SS' . [c_1 (c_2 + c_3) + c_2 c_3] = 0$... (3).

In the use of double resonance to secure an exalted effect, as in the experiments of Boys and of Callendar, the direct communication may be suppressed between the second resonator S′ and the external air. Then $c_3 = 0$, and the above becomes $p^4/a^4 + p^2/a^2 . [(c_1 + c_2)/S + /c_2 S'] + c_1 c_2/SS' = 0$...(4). To interpret the c's suppose first the passage between S and S′ abolished, so that $c_2 = 0$. The first resonator then acts as a simple resonator, and if p_1 be the corresponding p we have $p_1^2/a^2 = -c_1/S$, as usual. Again, if S be infinite, we have for the second resonator acting alone, $p_2^2/a^2 = -c_2/S'$. Hence (4) becomes $p^4 - p^2(p_1^2 + p_2^2 + S'/S . p_2^2) + p_1^2 p_2^2 = 0$...(5). In (5) if S′/S be very small, p^2 approximates to p_1^2 or to p_2^2, and this is the case of greatest importance in experiment. If p_1^2 and p_2^2 differ sufficiently, we may pursue an approximation from (5) founded on the smallness of S′/S. But it is of more interest to suppose that p_1^2 and p_2^2 are absolutely equal, which nothing precludes. Then $p^4 - p^2 (2p_1^2 + S'/S . p_1^2) + p_1^4 = 0$...(6), whence $p^2/p^2 = 1 + S'/2S \pm \surd(S'/S + S'^2/4S^2)$...(7), or if S′/S be small enough, $p^2/p_1^2 = 1 \pm \surd(S'/S)$...(8), p^2 differing but little from p_1^2 or p_2^2. It is also shown that $X_2/X_1 = \mp \surd(S'/S)$...(9). Now the ratio of condensations in the interiors are $(X_2/S')/[(X_1 - X_2)/S] = \surd(S/S')/[1 - \surd(S'/S)] = \surd(S/S')$ nearly...(10).

In some forms of the experiment we may have to deal rather with the flow through the passages than with the condensations in the interiors. The ratio of the total flows (or volumes transferred) is given in (9). But we may be more concerned with a comparison of flows reckoned per unit of area of the passages. In the case of passages which are mere circular apertures of radii R and R′ a simple result may be stated, for then $c_1 : c_2 = R : R'$; and, since $p_1^2 = p_2^2$, $c_1 : c_2 = S : S'$. Accordingly $(X_2/R'^2)/(X_1/R^2) = \surd(S'/S)\ S^2/S'^2 = (S/S')^{3/2}$...(11), and the advantage of a small S′ is even more pronounced than in (10). E. H. B.

323. *Possible Standard Source of Sound.* **C. T. Knipp.** (Phys. Rev. 12. pp. 491–492, Dec., 1918. Abstract of paper read before the Am. Phys. Soc., Dec., 1917.)—This paper describes a source of sound met with while blowing a mercury-vapour trap of pyrex glass. In its simplest form it consists of a vertical tube, open at the top and closed at the bottom, with the usual ring seal about two-thirds up from which place a smaller tube passes nearly to the bottom closed end. Just below the ring seal a side branch tube passes out horizontally with an open end. The top of the upright tube is closed with an adjustable cork piston and the closed bottom of this tube is heated to redness by a bunsen burner adjusted to give a fairly hot flame. When the tube begins to glow a pure tone readily audible over a large room is emitted from the branch tube. By attaching a horn to this tube the sound is increased many fold. The pitch is dependent on the length of upright and horizontal tubes. Though the only opening is at the mouth of the side tube, a candle flame placed there is instantly blown out. It is found that a current of air enters round the edge and another escapes along the axis. E. H. B.

324. *Perception of Sound.* **Rayleigh.** (Nature, 102. p. 304, Dec. 19, 1918).—Referring to a previous letter by W. M. Bayliss (*Ibid.* pp. 124–125, Oct. 17, 1918), in which the author's opinion was appealed to, the answer is stated to be largely one of words. Can we properly speak of the propagation of sound through an incompressible fluid? The author would answer, Yes.

There may be periodic motion and periodic variation of pressure ; the fact that there are no variations of *density* seems immaterial. Consider plane waves, corresponding with a pure tone, travelling through air. In every thin layer of air—and thin means thin relatively to the wave-length—there are periodic motion and periodic compression, approximately uniform throughout the layer. But the compression is not essential to the travelling of the sound. The substitution of an incompressible fluid of the same density for the gas within the layer would be no hindrance. Although there is no compression, there remains a periodic pressure and a periodic motion, and these suffice to carry on the sound.

Within the cavities of the ear, which are small in comparison with the wave-lengths of musical sounds, the water may certainly be treated as incompressible ; but the fact does not seem to be of fundamental importance in theories of audition. E. H. B.

325. *The Sound-Waves and other Air-Waves of the East London Explosion of January* 19, 1917. **C. Davison.** (Roy. Soc. Edinburgh, Proc., 38. 2. pp. 115–129, 1917–1918.)—Deals with the subject at greater length [see Abs. 529, 1295 (1917)], three maps being given of the sound area. L. H. W.

326. *Perception of Sound.* **D. F. Harris.** (Nature, 102, pp. 365–366, Jan. 9, 1919.)—In connection with the discussion on the physiology of the internal ear the author directs attention to the fact that a very few vibrations serve to establish the sensation of pitch. He then passes to the conclusion that instead of receiving and appreciating all the vibrations that arrive while a note lasts, the ear eases itself of such a burden by receiving only the few that suffice to settle the pitch. Nothing is said as to how the ear appreciates the continuance of the note. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

327. *The Electric Field in Systems of Regularly Arranged Point Charges.* **E. Madelung.** (Phys. Zeits. 19. pp. 524-532, Dec. 1, 1918.)—The calculation of the electric field in the interior of atomic lattices whose components carry electric charges offers great difficulties when the solution is sought by direct summation. At the same time the calculation is of great importance for ascertaining the nature and magnitude of the molecular forces acting between the atoms, in order to arrive at the conditions underlying crystal structure. The author now proposes formulæ which will materially facilitate the calculation of the electric field. Previous methods of this character have only been proposed by Ewald and Born, who develop the field in the element parallelopiped of the crystal according to three parametric Fourier series. The present author's formulæ not only converge more rapidly than those of Ewald and Born, but his method deals with static fields, whereas the latter authors have investigated dynamic fields only. Section 1 deals with the field given by a range of points in a straight line. Section 2 considers the field of a plane line-lattice. Section 3 investigates the field of a plane rectangular point-lattice, and section 4 of a plane acute-angled lattice. Section 5 deals with a space rectangular point-lattice, and section 6 with a mixed point series. Section 7 investigates a mixed plane line-lattice, section 8 a mixed rectangular plane point-lattice, and section 9 a cubical space-lattice. The paper is mathematical throughout. H. H. Ho.

328. *Electric Potential Gradient and Atmospheric Opacity at Kew Observatory.* **C. Chree.** (Roy. Soc., Proc. 95. pp. 210-234, Jan. 1, 1919.)—For many years past atmospheric opacity has been measured at Kew Observatory on a scale containing 13 steps. In this scale minimum opacity is denoted by 1, and is used when a chimney at 3850 yards is visible. The steps become very close at the other end of the scale where different fog intensities are provided for. For many purposes in the present paper these fog steps have been grouped together, reducing the total of 13 steps to the following six: 1, 2, 3, 4′, 5′, 6′. A study of the opacity figures shows that July emerges as the month of greatest visibility, while Nov. gives the poorest result. Except in winter, opacity 4′-6′ happens so rarely, that it is difficult to obtain satisfactory mean results at these opacities for any correlated phenomena. For the purposes of the comparison indicated in the title, mean potential gradients have been taken out for occasions of similar opacity. It is found that at all seasons the potential answering to opacity 2 is substantially greater than that answering to 1. Further, there is distinct evidence that the potential goes on increasing as the opacity rises in the scale. As regards the annual change, it further seems clear that if we confined ourselves to clear days, of opacity 1, we should obtain not merely a lower value for the year, but also a reduced difference between summer and winter. In considering the diurnal change in potential gradient on days of opacity 1 as compared with that from all selected quiet days we should still get a diurnal inequality of large amplitude with a maximum in the evening and a minimum in the early morning. The main difference would be that the secondary minimum in the early afternoon in winter would be largely if not entirely obliterated. In summer the double oscillation would remain nearly as prominent as before. Considering the effect of fog on the air-earth current, it is found that while the potential gradient is increased by fog the mobility of the ions is so greatly reduced that there is a substantial reduction in the current. J. S. Di.

DISCHARGE AND OSCILLATIONS.

329. *Light from Mercury Vapour.* **C. D. Child.** (Phil. Mag. 37. pp. 61-64, Jan., 1919.)—In a recent article by Strutt [Abs. 194 (1918)] a description is given of experiments on the luminous vapour coming from the discharge through gases at low pressure. The conclusion is reached in that paper that the light given off by the vapour comes very largely from the negative ions. The conclusion reached by Child during an investigation of the luminous vapour distilled from the mercury arc was that the light did not come from either the positive or the negative ions alone, but from the two at the moment of recombining [Abs. 320 (1914)]. In the present paper a discussion is given of Strutt's experiments and results, and it is shown that it is possible that the luminosity observed by Strutt was caused by recombination of positive and negative ions, and not by any action of the positive or negative ions alone. Further experiments are necessary before a definite conclusion can be reached concerning this phenomenon. A. W.

330. *The Emission of Positive Electricity by Salts of the Alkalies and Alkaline Earths, under the Action of Canal Rays.* **W. Völker.** (Ann. d. Physik, 57. 4. pp. 257-277, Nov. 15, 1918.)—The apparatus employed is described with the aid of a diagram and the following points are then considered, namely: The interception of the rays by metals, by lithium chloride, and by calcium sulphate. As the result of these experiments it is concluded that LiCl and $CaSO_4$ give off positive charges when they are placed so as to intercept canal rays of which the velocity is so high that they are able to produce on the surface of the salt the emission of the series lines of the metal. From this appearance alone it is not possible to draw any conclusion as to the nature of the positive charges given off by the salt. Stark has suggested that the intensity of the series lines of the metals, which are brought forth by the canal rays immediately in front of the salt on which they impinge, so much overbalances the intensity of the spectral lines of the negative radical of the salt that in the spectrographic appearance the series lines of the metals already appear brightly when the spectral lines of the negative radicals (Cl, O, S) are not yet visible. From this it would follow that the carriers of the positive charges given off by the salt would be atoms of the metals whose series lines are observed. In a new manner, therefore, the important result is obtained, that the positive atom ion is responsible for the series lines of an alkali or an alkaline earth. [See also Abs. 1528 (1912).] A. E. G.

331. *Theory of the Glow Discharge.* **R. Holm.** (Phys. Zeits. 19. pp. 548-556, Dec. 15, 1918.)—Among others the following points are considered:—Gradient of the positive column; Charge in the positive column; Layers in the positive column; Double ionisation limit in front of the kathode; Glow-light border which until now has not been explained; Explanation of the optical difference between the first (Hittorf) dark space and the glow-light border. [See also Abs. 1591 (1914).] A. E. G.

332. *Electric Oscillations.* **W. Schottky.** (Ann. d. Physik, 57. 7. pp. 541–567, Dec. 20, 1918.)—A theoretical discussion of the phenomena associated with electrical oscillations of small amplitude, with particular reference to sustained oscillations in vacuum tubes with two or with three electrodes. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

333. *Conductivity of Sea Water.* **H. R. Rivers-Moore.** (Electrician, 82. pp. 174–176, Feb. 7, 1919.)—The results given were obtained by a method due to Drysdale, and designed to overcome the polarisation errors which appear with alternating currents of only moderate frequency. A Tinsley-Drysdale inductance and capacity bridge was used. A telephone receiver was employed in place of a galvanometer, and in order to enable very small currents to be used a 3-valve amplifier was introduced when necessary. Frequencies were used varying from 0 to 100,000 per sec.

With samples of sea water taken from an estuary mouth values were obtained for the resistance of 26 to 27 ohms per cm.-cube at 15°C. No appreciable variation with frequency was observed. With samples from the open sea on the South Coast, the resistance found was from 24 to 25 ohms per cm.-cube at 15°C. The temperature coefficient was − 3 % per deg. C. [No analysis of the sea-water samples is given.] A. W.

334. *The Optimum Secondary Capacity of an Induction Coil.* **E. T. Jones.** (Electrician, 82. pp. 99–101, Jan. 17, 1919.)—A paper in which the effect of variation of the capacity of the secondary coil on the secondary potential and conversion efficiency is discussed. The results obtained from theory are confirmed by experiment. N. W. M.

335. *Electron Theory applied to Thermo-Electricity.* **G. Borelius.** (Ann. d. Physik, 57. 3. pp. 231–243, Oct. 29, 1918.)—Variation in the number of free electrons and change in their mean energy has been regarded as the fundamental cause in the explanation of thermoelectric phenomena on the electron theory. The results obtained do not agree satisfactorily with observed facts. The author considers that these changes contribute but a small moiety to the phenomena of thermo-electricity. The variations of the atomic field of force due to temperature changes have greater predominance. In the paper the origin of the Thomson-effect is discussed from this point of view, and the results arrived at are more favourably supported by observed facts. L. L.

336. *The Electronic Theory of Metallic Conduction.* **G. Borelius.** (Ann. d. Physik, 57. 4. pp. 278–286, Nov. 15, 1918.)—The author discusses the various electronic theories of conduction proposed by Drude, Riecke, Thomson, and others, pointing out in particular that the establishment of the Wiedemann-Franz law necessitates the assumption of the equipartition theory. This ascribes to the moving electrons the value αT for the kinetic energy. The insufficiency of the equipartition theory is most marked in its failure to account for the phenomena of specific heat and thermo-electricity. The author has previously shown that in the case of thermoelectric phenomena the experimental facts conform better with theory if the kinetic energy of the moving electrons be less than αT although still proportional to the absolute temperature. In the present paper the author

extends this point of view to electric and thermal conduction in metals. The metallic atoms under the action of forces of an electrical or gravitational nature occupy positions of equilibrium or execute vibrations about these positions of frequency ν. The conducting electrons in the intermolecular space will remain in a symmetric position for regular vibratory movements of the atoms. Interchange of energy takes place when the motion is irregular. The number of electrons is taken equal to the number of atoms, the combination of an atom and an electron forming a doublet which is more or less polarised by the application of an electric field. The formula established for the electrical conductivity (X) is $\frac{1}{3}\,\epsilon^2\nu/ru$, where ϵ is the electronic charge, r the atomic radius, and $u(=\mathrm{CT})$ the mean energy of the electron. The variations of X from metal to metal are due chiefly to variations of u and only slightly to the vibration frequency ν.

Thermal conductivity is accounted for by considering the wave propagation in the space-lattice due to the vibration of the positive atomic ions. Debye's expression for the thermal conductivity (λ) in a solid, namely, $\lambda = \frac{1}{3}\rho cq\mathrm{L}$, is taken as fundamental. $\rho c =$ specific heat per unit volume, $q =$ velocity of propagation of wave, $\mathrm{L} =$ mean free path. The mean free path of the atom is obtained by considering the energy-interchange due to the presence of the electrons. The author obtains $\lambda = \alpha^2\mathrm{T}\nu/ru$, that is, the thermal conductivity is approximately constant as experience requires. The Wiedemann-Franz law is also confirmed for $\lambda/\mathrm{X} = 2(\alpha/\epsilon)^2\mathrm{T}$, although the numerical factor is about 10 % greater than that found experimentally.

L. L.

337. *Some Peculiar Thermoelectric Effects.* **P. D. Foote** and **T. R. Harrison.** (Washington Acad. Sci., J. 8. pp. 545–549, Oct. 4, 1918.)—Deals with Benedicks' recent statement that a non-symmetrical temperature gradient in a homogeneous wire gives rise to a galvanometrically measurable thermo-e.m.f. The authors call attention to the fact that the existence of many of these curious thermoelectric forces, "rediscovered" every decade, has been well recognised for over a century, and point out that no conclusive evidence for their cause has been advanced although nearly all conceivable causes have at times been suggested. L. H. W.

338. *Universal Switch for Delicate Potential Measurements.* **W. P. White.** (Am. J. Sci. 46. pp. 610–612, Oct., 1918.)—For the construction to be clearly understood, the plan and elevation of the apparatus given in the original should be consulted. L. H. W.

339. *Frequency Transformer.* **T. Kikuchi.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 542–547, Dec., 1918.)—Describes, with diagrams, various circuits which may be employed with the dynatron [Abs. 300B (1918)] to give a multiplication of frequency. Thus, by applying to the plate and anode alternating voltages of different amplitudes the frequency may be trebled. The current of the dynatron-type frequency transformer is determined by the thermionic current from the filament, and can only reach a small magnitude. For this reason the arrangements described are of more theoretical interest than practical value. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

340. *Diamagnetism in Weak Fields.* **O. E. Frivold.** (Ann. d. Physik, 57. 6. pp. 471–488, Dec. 18, 1918.)—Honda found that the susceptibility of para- and diamagnetic elements varied with the field intensity [Abs. 1516 (1910)], indium being paramagnetic in weak fields and diamagnetic in strong fields. A similar effect has been observed by Overbeck and Weber in Zn-Cu alloys [Abs. 1335 (1915)], and it has been called metamagnetism. Gans has developed a theory [Abs. 721 (1916)] which deals with these effects and considers it uncertain that the effects are due, as Honda ascribes them, to slight iron impurities.

Measurements were made on pure diamagnetic elements in fields from 60 to 1000 gauss, employing the Curie method. The elements tested were Sb, Te, S, Zn, Ag, and Au. The material was prepared in a pure state and tested for iron, the iron content varying downwards from 0·025 per thousand in Sb. The experimental method and results are detailed; a variation of susceptibility with field was observed in weak fields in nearly all cases, zinc being an exception. Only in the case of gold did the change follow the course expected from Gans's theory. The susceptibility is more or less constant in strong fields except with silver, which behaves as a metamagnetic substance. The principal moments of inertia of the magneton and the number of magnetons per cm.^{3} were calculated for gold substance. G. E. A.

341. *The Energy of Magnetic Storms.* **S. Chapman.** (Roy. Astron. Soc., M.N. 79. pp. 70-83, Nov., 1918.)—In a magnetic storm there are three principal world-wide phases: (1) A rapid initial increase in H (Horizontal force). The energy involved in this is a very small fraction of the whole and is neglected in the present paper. (2) A much larger diminution in H lasting for many hours, and (3) a slow return to a normal magnetic field taking some days to accomplish. During the first half of the storm the total energy of the magnetic field in and around the earth is steadily increased, and this increase will at some stage attain a max. value E_0. After this it will gradually diminish as the electric currents in the earth and atmosphere die away converting their energy into heat. Taking into account the fact that this dissipation of current-energy into heat is going on during the whole storm and not only during the period of decay, it is found that the total energy to be supplied by the external forces in the course of the storm is approximately equal to $2E_0$. If δH_0 is the max. mean diminution of horizontal force along the equator, it appears by calculation that E_0 is nearly proportional to δH_0 and not to the *square* of the intensity of the disturbance as has generally been supposed. The excess energy of the field is made up of two terms: (*a*) the energy of the disturbance field if it existed by itself in the absence of the permanent field, or the "Self-energy integral," and (*b*) a term which depends upon product terms of the excess field and normal field, or the "Joint-energy integral." It has usually been assumed that the latter is of negligible magnitude, but it is here shown to be very much the most important term of the two. Thus for a storm in which $\delta H_0 = 100\gamma$ the calculations lead to the numerical result: Joint-energy integral $= 4{\cdot}2 \times 10^{22}$ ergs; Self-energy integral $= 0{\cdot}4 \times 10^{20}$ ergs, or one-thousandth part of the former. It has already been pointed out that the total energy of the storm equals approximately twice the sum of the above two terms, that is, in round figures 10^{23} ergs. The temporary supply of energy in everyday units is calculated to be at the rate of 270 million H.P. This rate is only one-millionth part of that at which solar heat energy is being supplied to the earth.

As regards the source from which the energy of storms is derived, the heat energy of the atmosphere is considered and found to be inadequate. The rotational energy of the earth is amply sufficient, but it is difficult to conceive of a process by which its transformation could be effected. The author's view is that the energy is obtained from streams of electric corpuscles emitted from the sun. The theory outlined is shown to be free from the objections which have been raised against certain other theories of the same broad type. J. S. Di.

342. *Magnetic Observations at the Time of the Solar Eclipse, June* 8, 1918. **D. L. Hazard.** (Terrest. Magn. 23. pp. 111-120, Sept., 1918.)—On the occasion of this eclipse the United States Coast and Geodetic Survey arranged three field stations in the belt of totality for the observation of the magnetic elements during the eclipse. Eye readings of declination were made every minute for six hours, while for 20 mins. about the time of totality they were made every 30 seconds. Air temperature readings were taken every five minutes. Eye readings of declination were also made every five minutes over the same six-hour period at the five permanent observatories of the Survey, and at these stations readings of the three magnetic elements were taken from the magnetographs at the same intervals. Tables are given setting out the data obtained in considerable detail. The diurnal variation found on the occasion of the eclipse agreed very closely with the mean from the ten quiet days of the month. J. S. Di.

343. *Magnetic Declination at Agincourt and Meanook.* **W. E. W. Jackson.** (Terrest. Magn. 23. pp. 127–136, Sept., 1918.)—In July, 1916, a magnetic observatory was established at Meanook (54° 37′ N., 113° 21′ W.) at which declination is continuously recorded. The first calendar year's data (1917) are here compared with the corresponding results from Agincourt (43° 47′ N., 79° 16′ W.). Declination shows greater fluctuations at Meanook than at Agincourt, the mean absolute diurnal range being about double in the late summer but less markedly greater in the winter. In the mean daily variation the first two harmonic terms are of most importance, the 24-hour term being considerably greater at Meanook than at Agincourt, while the 12-hour term is approximately equal at the two stations in summer but greater at Agincourt than at Meanook in equinox and winter. Certain magnetic storms which are illustrated show great differences as between the two stations. J. S. Di.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

344. *A New X-ray Unit in Radiotherapy.* **S. Russ.** (Archives of Radiology, No. 211. p. 226, Dec., 1918. Nature, 102. p. 412, Jan. 23, 1919. Abstract.)—The unit termed a "rad" is based on the amount of radium which, when applied to malignant tumour cells, causes complete inhibition of their power to grow after an exposure of one hour. This is determined by tests on rat-cancer. For measuring the dose of X-rays administered to a patient, the photographic action of the rays is obtained on a photographic plate, and upon the same plate is impressed the photographic action of the standard radium. The plate is developed and a comparison made between the photographic impressions so obtained. For example, if the X-ray tint for an exposure of 10 secs. equalled that obtained with an exposure of 6 secs. with the radium, the dose of X-rays during the 10 secs.' exposure would be 1/600 "rad."

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

345. *Calculation of the Place of a Chemical Element in the Periodic System from its Atomic Weight and Density.* **K. Fehrle.** (Phys. Zeits. 19. pp. 532–533, Dec. 1, 1918.)—From the equation $\sqrt[3]{\left(\frac{A^4 \times 0\cdot076}{S \times 1\cdot008^4}\right)} = \left\{\frac{\theta\sqrt[3]{(4\pi/3)}+1}{2\pi\sqrt[3]{(4\pi/3)}+1}\right\}^3$, where A is the atomic weight and S the specific weight of an element in the solid state (in the neighbourhood of absolute zero where possible), every value of $\sqrt[3]{\left(\frac{A^4 \times 0\cdot076}{S \times 1\cdot008^4}\right)} = r$ gives a value of θ and thence a series of points on the spiral curve $r = \left\{\frac{\theta\sqrt[3]{(4\pi/3)}+1}{2\pi\sqrt[3]{(4\pi/3)}+1}\right\}^3$. This expression for r was found in an earlier communication [Abs. 1142 (1918)] to be proportional to the motion of atoms at equal angular velocities. If this result be applied to all elements, it is found generally that the points lie upon radii vectores which are coincident or turned through multiples of $2\pi/7$ with respect to each other. Those values which lie on the same radius vector correspond to elements in vertical columns of the periodic table, *i.e.* to the same family. The values of θ belonging to the separate elements of the same vertical series are therefore multiples of 2π. The author then develops the values of the various elements as multiples of hydrogen + multiples of helium. It is noteworthy that according to this mode of representation the triad group coincides with the seventh group.

A spiral diagram accompanies the paper. H. H. Ho.

346. *Investigation by Means of the X-rays of the Crystal Structure of White and Grey Tin.* **A. J. Bijl** and **N. H. Kolkmeijer.** (K. Akad. Amsterdam, Proc. 21. 3. pp. 405–408, 1919.)—In a previous communication [Abs. 1140 (1917)] the application of the Debye and Scherrer method of examining small crystals by means of X-rays to the case of the chief modifications of carbon has been described. The authors now describe the application of the method to white and grey tin. A number of precautions taken to avoid the interference of several factors are described. The photographs obtained indicate that grey tin is crystalline but that it possesses a crystal structure different from that of white tin. F. C. A. H. L.

347. *Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass.* **W. H. Bassett** and **C. H. Davis.** (Am. Inst. Mining Eng., Bull. No. 145. pp. 57–78, Jan., 1919.)—This paper deals with the grain-size of cartridge brass and its relation to the Brinell hardness-number; it is illustrated by a series of excellent photomicrographs and the conclusions arrived at are as follows:—The grain sizes of annealed alloys 68 Cu, 32 Zn and 69 Cu, 31 Zn, agree closely when the previous heat treatment and reduction by rolling correspond. The grain sizes of brasses annealed at low temperatures are greatly affected by the grain size and the reduction by rolling, previous to such annealing. In the case of brass 68 Cu, 32 Zn, Brinell hardness indicates grain size. The finer the grain size of the previous anneal the more nearly will Brinell hardness and grain size approach the standard curve. C. O. B.

348. *Occluded Gases in Ferrous Alloys.* **G. Alleman and C. J. Darlington.** (Frank Inst., J. 185. pp. 461–480, April, 1918.)

349. *Spontaneous Generation of Heat in Recently Hardened Steel.* **C. F. Brush, R. A. Hadfield, and S. A. Main.** (Roy. Soc., Proc. 95. pp. 120–138, Oct. 7, 1918.)—A further communication dealing with the effect mentioned in Abs. 564 (1917) and 586 (1918). The paper is divided into two sections. The first, after a recapitulation of the previous work, describes and discusses the results of the new researches; in the second portion an empirical law is found which seems to regulate approximately the gradual diminution of the evolution of heat. The experimental work was mainly confined to variation of heat treatment of one particular Ni-Cr steel, though certain other materials were examined; the results being summarised as follows:—(1) The rate of evolution or absorption of heat by quenched steel is, after a short initial period, approximately in reverse ratio to the time elapsed after quenching. (2) The actual rate of evolution has been determined for various specimens. (3) The rate of contraction of quenched steel was found to follow the same law as the rate of evolution or absorption of heat. (4) This suggests that the contraction is intimately connected with the heat evolution, both being due to the same cause. L. H. W.

350. *Comparison between the Internal Elastic Equilibrium of Quenched Alloys with that after Cold-drawing.* **A. Portevin.** (Comptes Rendus, 167. pp. 1033–1035, Dec. 23, 1918.)—In studying the relative effects of quenching and of cold-drawing upon the internal stresses in alloys, a brass with 60 % Cu and a modulus of elasticity of $9\cdot5\times10^3$ kg./mm. was chosen. The quenching was carried out in water from 760° C., the diam. of the bar used being 20 mm. The outside of this sample was found to be subjected to a compressional stress of 14 kg./mm.^{2}, and the centre stressed in tension to about 16 kg./mm.^{2}, whilst the neutral position was approximately half-way through from surface to centre. The stress distribution for the severely cold-drawn wire whose diam. was 16·5 mm. was similar *but in the opposite sense.* The surface was in tension (22 kg./mm.^{2}), the centre in compression (16 kg./mm.^{2}) and the region of zero stress was rather nearer the surface than the centre. A cold-drawn bar of 40 mm. diam. was quenched from 850° C., the stresses ranging from -11 to $+24$ kg./mm.^{2}, at the surface and centre respectively, and it is suggested that by a preliminary quenching it might be possible to subject the brass to a more severe drawing without producing rupture. F. C. T.

351. *Migration of Ions in Liquid Crystals of Ammonium Oleate Hydrate.* **O. Lehmann.** (Ann. d. Physik, 57. 3. pp. 244–256, Oct. 29, 1918.)—When a capillary tube containing liquid-crystalline ammonium oleate hydrate is surrounded by a solution of sal ammoniac into which electrodes are inserted, it is found that, while the electric circuit is not closed, thread-like processes grow out of the capillary tube. These are due to the fact that the ammonium oleate hydrate combines with the water of the sal ammoniac solution to form more highly hydrated material. On closing the electric circuit, the production of the thread-like processes is accelerated at the end directed towards the positive electrode, and retarded at the other end, if the potential amounts to about 4 volts. On increasing the potential to 110 volts, a streaming of the thread-like processes takes place, and these then break off and dissolve. In a short time a pointed boundary of grained structure is formed in the tube between the less hydrated and more hydrated salt which wanders through the tube. When the less hydrated ammonium oleate adheres to the walls of the capillary, coloured interference bands are observed between crossed nicols. A number of interesting phenomena are observed, which are illustrated in the paper, and which require these illustrations for their understanding, the phenomena being explained by a re-formation of ammonium oleate hydrate due to a wandering of ions and the arrangement of the oleate between the molecules present. A. F.

352. *Osmotic Action of Solutions of Cane-sugar, Silver Nitrate, and Lithium Chloride in Pyridine, when separated from Pyridine by a Rubber Membrane.* **A. E. Koenig.** (J. Phys. Chem. 22. pp. 461–479, Oct., 1918.)—The author has determined the osmotic pressures of pyridine solutions of the above substances using a rubber membrane and finds that the pressures for the sugar solutions are nearly equal to those calculated according to the gas laws, but that in the case of silver nitrate and lithium chloride the pressures are lower than those of the sugar solutions of corresponding molecular concentration. In the experiments it was found that after having reached a maximum, the pressure gradually decreased. This seemed to be due to an alteration in the nature of the rubber owing to its contact with pyridine. Membranes used a number of times, with fresh solutions, did not give as high pressures as the previously unused rubber. The same solution used several times, each time with a fresh membrane, yielded practically the same pressure. This would lead to the conclusion, previously stated by Kahlenberg [Abs. 1142 (1906)], that the magnitude of the pressure developed by a given solution depends on the nature of the semi-permeable membrane. A. F.

353. *Constitution of Tin Bronzes.* **S. L. Hoyt.** (Am. Inst. Mining Eng., Bull. No. 144. pp. 1721–1726; Disc., 1726–1727, Dec., 1918.)—Deals with the upper heat effect in the copper-tin alloys over the $\alpha + \beta$ range. In the case of Cu-Sn-Zn alloys containing major portions of Sn and minor portions of Zn two marked heat effects were noted at 520° and 600° C., instead of the one effect generally observed in either of the two binary series. In the case of pure Cu-Sn alloys the two breaks have been found, that occurring at about 600° being well marked but somewhat weak. A series of photomicrographs are given showing the effect of heat treatment between 400° and 700° C. and the change of simple $\alpha + \beta$ phases to more complicated systems, in the case of an alloy containing Cu 75, Sn 15 and Zn 10 %. C. O. B.

354. *The Passivity of Metals.* **J. Stapenhorst.** (Zeits. Phys. Chem. 92. pp. 238–254, April 24, 1917. Dissertation, Münster.)—The author wishes to test the common views held: (1) The oxygen theory, that metals are normally active but become passive by oxygen, by forming either an oxide film or an alloy; (2) the hydrogen theory, that metals are normally passive and are activated by hydrogen; and intermediate views. Some of his experiments are modifications of those of Rathert. Iron made passive in chromic acid becomes active when charged with hydrogen ions. The experiments can be so arranged that the hydrogen diffuses through a steel foil (sometimes perforated), the other side of which is in contact with chromic acid. This experiment favours the hydrogen theory, but it does not prove that iron is activated only by hydrogen; the oxygen plays a part. The potential assumed by a metal in a neutral electrolyte depends upon the oxygen content of the solution; when the surface is renewed by grinding, the potential changes from the passive to the active value. Roughening the surface tends to activate, polishing the surface to passivate, the metal. In a solution saturated with hydrogen or nitrogen the metal assumes the same low potential value as in the solution when free of gas; the hydrogen and nitrogen are hence indifferent gases. Of the three gases, H, N, O, oxygen is the only one capable of influencing the solution tension of the metal; both in the gaseous and dissolved states it affects the electrode potential. The natural potential of a metal is only then a measurable constant quantity when it is defined as the p.d. between the pure metal and the pure electrolyte, the condition of purity necessitating also the absence of gases.

H. B.

355. *Electrolytic Estimation of Metals without the Use of an External Source of Current.* **M. François.** (Comptes Rendus, 167. pp. 725–727, Nov. 11, 1918.)—A strip of nickel or other conducting metal is placed across the top of a Pt crucible, and a zinc rod is suspended from the strip in such a way that it reaches nearly to the bottom of the crucible; there is metallic contact between the zinc and the strip. The zinc rod is amalgamated at least 24 hours before being used, and is wrapped in filter paper, which is tied on to the rod with cotton. When the crucible is filled with an electrolyte containing the metal to be estimated, an electric circuit is completed, the zinc dissolving and the metal of the electrolyte being deposited on the sides of the crucible. Silver and gold are deposited from the alkaline solution of their complex cyanides and mercury from a sulphuric acid solution containing potassium iodide. Twenty-four hours are required for quantitative deposition, but the weight of metal which can be so deposited in that time is not stated.

T. S. P.

356. *Electro-deposition of Iron from Organic Solvents.* **E. H. Archibald** and **L. A. Piguet.** (Roy. Soc. Canada, Trans. 11. pp. 107–112, Dec., 1917, March, 1918.)—In the experiments described Pt electrodes were used in most cases, the temperature being approximately 25°. The results obtained may be summarised as follows:—Iron can be completely deposited electrolytically from a solution of its chloride in acetone, acetone and water, or acetone and ethyl alcohol. From the acetone and the acetone-water solution the iron can be deposited entirely free from carbon. At low voltages the iron is deposited from these solutions in the metallic form, but as the voltage is increased it comes down as a red deposit, which adheres to the electrode and allows the iron to be removed from the solution. From the acetone-alcohol solutions the iron, although completely deposited, is contaminated with carbon. From acetone-water solutions of ferrous sulphate iron can be completely deposited, but again the deposit contains considerable quantities of carbon. It is possible that these results could be used as a basis for a method of separating iron from other metals, such as Al and Cr, but much further work in this direction will be necessary. Aldehyde is not formed during the electrolysis of the acetone solutions.

T. S. P.

357. *Electrolytic Precipitation of Zinc.* **D. McIntosh.** (Roy. Soc. Canada, Trans. 11. pp. 118–119, Dec., 1917–March, 1918.)—In the experiments described, 2500 cm.^{3} of a solution of zinc sulphate containing 4–5 % of zinc were electrolysed between a lead anode and an Al kathode, the current density, for the most part, varying from 20–30 amps. per sq. ft. In general the electrolysis was continued until the zinc had been brought down to about 0·5 %, the acid having increased to 6·7 %. Various impurities were added to the solutions before electrolysis, and the effects produced are illustrated by a series of photographs. In order to obtain good deposits of zinc the electrolyte must be quite clear and free from colloids. The percentage of iron present must be low, much less than 0·1 %, although when Mn is present in equal amount to the iron satisfactory deposits can be obtained in the presence of 0·1 % of iron. Arsenic, Sb, Cu, Co and Ni, and in general metals more electro-positive than zinc, must be absent. The solution, particularly in tanks containing large amounts of acid, should be cold. The zinc deposits in a semi-passive form, but when it begins to dissolve solution cannot be stopped in any simple way. The zinc concentration should be as high as possible (6–7 %) and no attempt should be made to electrolyse solutions containing less than 2·0 — 1·5 % of zinc. With the ordinary cascade system the optimum current density is 25–30 amps. per sq. ft. When the solution contains a considerable amount of acid, 2·4 to 4·7 %, a current density of 40 amps. per sq. ft. still gives satisfactory results.

T. S. P.

358. *Purification of Gallium by Electrolysis and the Compressibility and Density of Gallium.* **T. W. Richards** and **S. Boyer.** (Nat. Acad. Sci., Proc. 4. pp. 388–390, Dec., 1918. Am. Chem. Soc., J. 41. pp. 133–134, Feb., 1919.)—The method of separating gallium from indium by means of the different solubilities of the hydroxides in caustic alkali does not give good results. Making use of the fact, however, that Ga occupies a place in the electrolytic series between In and Zn, the authors have succeeded in obtaining pure Ga by carefully regulating the hydrion concentration and current density during electrolysis. Details are not given. The melting point of pure Ga is 30·8°; the compressibility of the solid is $2{\cdot}09 \times 10^{-6}$, placing the metal precisely on the curve joining the other compressibilities in the graph representing the periodic relation of this property to atomic weight. Liquid Ga has a compressibility of $3{\cdot}97 \times 10^{-6}$ at 30°. The densities of the solid and liquid metal were respectively 5·885 and 6·081 [presumably at the freezing point !].

T. S. P.

359. *Hydrogen Overvoltage.* **D. A. MacInnes** and **L. Adler.** (Am. Chem. Soc., J. 41. pp. 194–207, Feb., 1919.)—With one exception, none of the published theories of overvoltage [compare Abs. 841 (1916)] attempts an explanation of the great influence the physical condition of the electrode may have on overvoltage. The authors believe that the results of their present investigation throw light on this difficulty, and they consider that hydrogen overvoltage is due, primarily, to a layer of supersaturated and dissolved hydrogen in the electrolyte surrounding an electrode. If, however, the electrode can adsorb large hydrogen-gas nuclei to start bubble formation, the supersaturation cannot rise to high values, and the electrode will have a low overvoltage. Metals with small adsorptive powers hold small nuclei and have high overvoltages. Using a special apparatus, evidence has been collected in support of this explanation, as follows: (*a*) The presence of nuclei has been observed experimentally; (*b*) by observations on fluctuations of the voltage during the evolution of a single minute bubble; (*c*) by showing that a quantitative relation exists between the size of the bubbles and the overvoltage at platinised platinum electrodes; (*d*) by observations on the sizes of bubbles from electrodes of various metals; (*e*) by the agreement, as predicted by the theory, of the direction of the variation of the overvoltage with the pressure.

T. G. P.